U.S. DEPARTMENT OF COMMERCE
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PB-292 555

A Computer Study of the Koh-Chang Model for Dredged Material Disposal

(U.S.) Corvallis Environmental Research Lab

Mar 79

PB 292555

A COMPUTER STUDY OF THE KOH-CHANG MODEL FOR DREDGED MATERIAL DISPOSAL

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TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/3-79-027	2.	3. RECIPIENT'S ACCESSION NO. PB292555
4. TITLE AND SUBTITLE A Computer Study of the Koh-Chang Model for Dredged Material Disposal		5. REPORT DATE March 1979 issuing date
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) A. M. Teeter and B. H. Johnson		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Environmental Protection Agency, Corvallis Environmental Research Laboratory, Corvallis, OR U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS		10. PROGRAM ELEMENT NO.
		11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Same as above		13. TYPE OF REPORT AND PERIOD COVERED
		14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This report is on a computer study of the Koh-Chang model for physical fate prediction in dredge material disposal. This computer model can simulate three discharge methods: instantaneous bottom release, jet discharge, and discharge into a wake. Convective descent, dynamic collapse or bottom encounter, and long term diffusion phases of waste behavior are considered. Simulation results are most sensitive to variations in convective entrainment and form drag coefficients in the bottom dump method. In the jet method, the model is most sensitive to convective entrainment and cloud gradient coefficients. Model analysis on a single discharge opening with the results superimposed to represent the entire discharge is often necessary. The model is applied to five field situations for pipeline, hopper dredge, and bottom opening scow. Insufficient field data are available for validation. Modification to the model have been made by COE-WES and EPA-CERL subsequent to this study.

Modifications

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Dredge Material Disposal Mathematical Model		13/B

18. DISTRIBUTION STATEMENT Release to Public	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES 133
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE A07 - A01

EPA Form 2220-1 (9-73)

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ABSTRACT

A cooperative computer study was undertaken by Environmental Protection Agency and Corps of Engineers personnel to evaluate the Koh-Chang model for application to dredged material disposal. Disposal of dredged material into tidal waters can come from pipeline, hopper dredge, or bottom opening scow. The material can be in the form of slurries or compactions or combinations of both. Six classes of discharge conditions are suggested which cover most actual cases. The Koh-Chang model can aid fate prediction and thus provide a broader base for understanding the ecological effects of this type of waste disposal. This computer model can simulate three discharge methods: instantaneous bottom release, jet discharge, and discharge into a wake. Convective descent, dynamic collapse or bottom encounter, and long term diffusion phases of waste behavior are considered. Model input requires that ambient conditions, barge and/or discharge characteristics, waste characteristics, plus coefficients and control parameters be specified. Sensitivity of the model to its input coefficients was first studied to assess the model's utility. In the bottom dump method, output results are most sensitive to variations in convective entrainment and form drag coefficients. In the jet method, the model is most sensitive to convective entrainment and cloud gradient coefficients. Though additional study is needed, the sensitivity of the model to reasonable ranges of input coefficients is less than expected. In most cases coefficients built into the model are adequate. Also, sensitivity to input condition uncertainty is not great. Information on the Columbia River ocean disposal site was used as input to the model. Two schemes representing multiple port discharges were tried. Model analysis on a single discharge opening with results superimposed to represent the entire discharge seems to be the most accurate method available in the model for this representation. Input conditions were altered through their estimated ranges. The model operated properly even though the output characteristics covered a considerable range. The model was less tolerant when extremely large jets (250 ft^2) were considered. Model runs were performed on a near-instantaneous discharge off New Haven, Connecticut. Stationary pipeline discharges can only be run for the convective phase of the model. Information on spoil agglomerations discharged and their subsequent behavior is scarce. Although different from slurries, their behavior would also vary with cohesiveness. A model run based on a 2,000 yd^3 cohesive spoil discharge off Rhode Island was made. For this computer run, the entrainment coefficient was reduced by a factor of 25. The waste cloud in the model, as observed in the field, descended almost unaltered and spread out upon impact.

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LIST OF ABBREVIATIONS, SYMBOLS, AND METRIC EQUIVALENTS

ABBREVIATIONS

Fn	Froude number
ft	feet
ft/sec or fps	feet per second
g	gravity
gm/cc or gm/cm^3	grams per cubic centimeter
Re	Reynolds number
yd	cubic yard
2-D	two dimensional

SYMBOLS

A, a	minor axis
B, b, R	radius or major axis
$C_D, C_{D_3}, C_{D_4}, C_{DRAG}$	drag coefficients
C_M	apparent mass coefficient
C_1	constant ($\sim$ 0.16)
C_{FRIC}	friction coefficient
e_{2_1}, e_{2_2}, e_{2_3}	vertical diffusion coefficient
Fl, FRICTN	friction coefficients
K	vorticity
M_a	apparent mass
p	porosity of deposited solids
Roo	bulk density of waste or waste cloud
Ua	X component of ambient current
W	volume of waste deposited
W_a	Y component of the ambient current
$\bar{Y}$	vertical mass centroid depth
Ye, Ye_2, Ye_3, Ye_4	depths where vertical diffusion coefficients are specified
Yu, Yw, Ye	depths where ambient currents are specified
Y, y	depth
Y'	Distance from lower boundry

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LIST OF ABBREVIATIONS, SYMBOLS, AND METRIC CONVERSIONS (CONTINUED)

α, α_0, α_c, α_1, α_2, α_3, α_4	entrainment coefficients
γ	cloud gradient factor
β_0	settling coefficient
ε	density gradient, $-(1/\rho_0)\ \frac{d\rho}{dy}$
λ	dissipation parameter based on size
ρ	density
ρ_a, ρ_0	ambient densities
ρ_s	density of waste solids
ρ_1	density of waste liquid
$\Delta\rho$	density difference between waste cloud and ambient at $Y' = 0$
σ_x^2, σ_z^2	variances of diffusing waste cloud
σ_{xz}^2	co-variance of diffusing waste cloud

METRIC EQUIVALENTS

1 ft	0.3048 meter
1 ft^2	0.0929 square meter
1 ft^3	0.02832 cubic meter = 28.32 liters
1 (cubic) yd	0.765 cubic meter

SECTION I

INTRODUCTION

BACKGROUND

The purpose of this study is to document the use of a mathematical model to describe the behavior of dredged materials as they are released from barges. It is a cooperative study between the Corps of Engineer's Waterways Experiment Station and the Environmental Protection Agency's Corvallis Environmental Research Laboratory undertaken primarily to evaluate the Koh-Chang mathematic model (1) for this purpose.

The Corps of Engineers has primary responsibility for administering a permit program for the dumping of dredged material at established dumpsites. This authority was granted by the Federal Water Pollution Control Act Amendments of 1972 and the Marine Protection, Research, and Sanctuaries Act of 1972 which also requires the review and concurrence of the Environmental Protection Agency in following the two criteria applicable: one for inland navigable waters and one for ocean waters. Both agencies, therefore, have a practical interest in the behavior of the dredged material as well as the potential ecological and environmental impacts and the public health, recreation, and economic considerations involved. There are currently 106 designated disposal sites for dredged material. Most of these are in inland navigable waters. In 1968, about 80 percent of all wastes discharged into the ocean from barges was dredged material, amounting to over 38 million tons (2). The total open water dredged material disposal is about 200,000,000 yd annually, 70 percent from hydraulic pipeline operations. Open water is considered rivers, lakes, bays, estuaries, and the ocean (3). Some of the reported effects of dredging and disposal activities include a temporary reduction in fish populations and dissolved oxygen as well as increased turbidity and available nutrients.

Since field investigations of the fate of dredged material disposed of in this manner are inadequate in most cases and come after the fact, a generalized mathematical model which could simulate the disposal operation would be invaluable to the management of dumpsites. Also, if discharges could be accurately modeled, research into possible disposal operation modification which might minimize the resulting environmental effects would be greatly streamlined. Equipment and procedural changes could be tested for effectiveness by a computer model prior to operation. Examples of changes which have been considered are the releasing of dredged material 45 feet below the surface of the water through a large pipe and altering the speed and discharge rate of the disposal vessel (4). Mathematical modeling would permit evaluation of the change in environmental effects against the economic considerations.

In March 1974, a report on existing mathematical models for the physical fate prediction of material disposed in an aquatic environment was published by the Office of Dredged Materials Research (ODMR) at the U.S. Army Engineer Waterways Experiment Station (WES) (5). This report concluded that the most significant modeling effort found was a mathematical model to predict dispersion and settling in barged ocean disposal of wastes developed by R.C.Y. Koh and Y. C. Chang and funded by the Coastal Pollution Branch of the Environmental Protection Agency's Pacific Northwest Environmental Research Laboratory. The report further concluded that the model was applicable to the disposal of dredged materials with the following major limitations:

A. The model is limited to application in an ocean type environment.

B. The model contains many coefficients, some of which are not easily specified.

C. No field, and only limited laboratory, verification of the model has been conducted.

The results of the above study were then used to aid in the formulation of the ODMR's research plans in this area. For example, Tetra Tech, Inc. has been awarded a contract to modify the model for use at estuarine disposal sites. In addition, as a result of the study recommendations, plans for field verification and sensitivity analysis of the Koh-Chang model were incorporated into the aquatic disposal research program of the ODMR.

At the same time that the ODMR's research plans were being formulated, the Coastal Pollution Branch of the EPA's Pacific Northwest Environmental Research Laboratory was becoming involved in a computer study of the model. At this point, it was agreed by both the Coastal Pollution Branch and the ODMR that a joint effort along the lines of a sensitivity study would benefit both groups. Such an effort would provide insight into model performance on the Corps GE-635 computer as compared to model results from the EPA's CDC-6400. In addition, obviously, such a joint study would reduce unnecessary duplication of effort.

PURPOSE AND SCOPE OF THIS STUDY

Before one can place a reasonable degree of confidence in a computer model containing many coefficients, an understanding of the dependence of model output on those coefficients must be obtained, i.e., a sensitivity analysis must be conducted. In addition, one would like to know to what extent various types of discharges can be characterized by the model and the range of input conditions within which the model operates properly. An analysis of the Koh-Chang model, through a computer study, to yield information on these questions was the major objective of the study described herein. An additional objective was to investigate model sensitivity to possible measurement errors in input data.

The Koh-Chang model, discussed briefly in this text, can be applied to material disposed of by instantaneously dumping from the bottom of a barge or hopper dredge as well as to disposal through nozzles under a moving vessel. In tracing the material through the water column, a possibility of 17 coefficients are encountered in the bottom dump method and 19 in the nozzle discharge method. The sensitivity of the model to each of these coefficients, with the exception of re-entrainment coefficients associated with bottom deposits and floatables at the surface, was conducted in the following manner. For each disposal option, each coefficient was individually varied about the value estimated by Koh, with all remaining coefficients set to their respective suggested (Koh) value. The range of variation was rather subjectively set; a major guide was the inclusion of extreme values. Final model output, related mainly to bottom deposit computations, was then compared for the different values of each coefficient. The re-entrainment coefficients for bottom material were not investigated since the assumption of negligible bottom currents was made and thus material that settles to the bottom remains there. The coefficients related to floatables at the surface were not considered since the material dumped was assumed to contain only heavy particles. In addition to determining model sensitivity to the many coefficients, a series of computer runs to determine output dependence upon minor variation of such input data as the ambient conditions and material characteristics was also made and results are presented.

Application of the model was then made to dredged material disposal operations at several sites. Where possible it was intended to select real examples for each of six types of disposal operations and in this way test the model's general applicability. This proved no problem except when agglomerations were considered. Information on this aspect of the problem is very sketchy, and for combinations of slurries and agglomerations, seemingly nonexistent. Five examples of different types of discharges were developed, one of which is purely hypothetical though not unreasonable. Some comparisons with field data are possible. The Columbia River ocean disposal site was used as an example of a slurry jet discharge lasting many minutes. Various runs were made for this case in which input parameters such as jet size and vessel speed were varied to determine the range of operating conditions within which the model performed properly. These results should be useful in applying the model to an actual disposal operation.

SECTION II

SUMMARY

The Koh-Chang model is a mathematical model for predicting the short term physical fate of material dumped into the ocean. The model contains several coefficients which either must be specified by the user or the user may accept the values programmed within the model. One objective of this research effort was to investigate, through a computer study, the sensitivity of model output to variations in the many coefficients contained within the model. Such an analysis should provide the user with a greater degree of confidence; although, ultimate confidence in the model, or for that matter any mathematical model, must necessarily await laboratory and/or field verification. An additional objective was to investigate model performance when applied to an actual dredged material disposal operation. Information on the range of input conditions within which model computations proceed normally should be beneficial to the prospective model user.

The basic input data to the model can be grouped into three categories: (a) specification of the ambient environment, (b) a description of the material being dumped, and (c) physical characteristics of the disposal method plus various control parameters. In the model performance analysis, the ambient environment was prescribed by values which might exist at the Corps' Columbia River ocean disposal sites. For different types of material or disposal in a different ambient environment the model sensitivity would vary. For example, if a dump consisting of very fine material is made and results in the cloud collapsing in the water column with a resulting long time required for deposit of the material on the bottom, the dominant factor in the location of the material will be the ambient current and the particle settling velocity. Therefore, low model sensitivity to most coefficients will probably be observed. Similarly, if the cloud is extremely dense and/or the disposal site very shallow the cloud will probably hit the bottom within seconds. With the material deposited on the bottom within such a short time, again less model sensitivity to most coefficients will probably be observed. It is believed the hypothetical input data used in the sensitivity study result in relatively high model senstivity being displayed for most coefficients and thus produce a meaningful analysis. In addition to ambient conditions, other input data used in the study of model performance reflect an actual dredged material disposal at the Columbia River site.

A series of model runs in the sensitivity study made was for the case of an instantaneous bottom dump disposal. For all values of all coefficients, except α_o which is associated with the entrainment coefficient, the cloud hit the bottom during convective descent and subsequently collasped on the bottom. Thirteen coefficients were varied and the model output compared to assess model sensitivity. Since the material did reach the bottom rather quickly, the only output investigated was percent solids on the bottom, distance to the centroid of bottom deposits, and spread of bottom material about the centroid. To be consistent in summarizing model sensitivity to the various coefficients, the following rating system is used. If the maximum variation in model output is 10 percent or less, the sensitivity is classified as low. However, for maximum variations on the order of 10 to 50 percent, model sensitivity is considered medium; variations above 50 percent classify the model sensitivity as high. Table 1 illustrates in tabular form model sensitivity to the various coefficients. Note that 9 of the coefficients - C_m, α_c, C_{D_3}, C_{D_4}, γ, C_{FRIC}, F_1, FRICTN and λ - appear to exert a very minor influence upon model output. Of the remaining 4, the model seems to be quite sensitive to 2 coefficients; namely α_o, and C_{DRAG}. In actuality α_o is not expected to vary nearly as much as indicated in Table 1.

The next series of model runs was made for the same ambient and material input data, but with disposal accomplished by discharging the material through a nozzle under a moving barge, i.e., the jet discharge mode. For all values of all coefficients, the plume reached a neutrally buoyant position in the water column within the first 50 ft and collapsed. Since the material remained in the water column for an extended time, in addition to plots related to the bottom deposit output, it was decided to also compare output related to computations within the water column. In particular, plots of the vertical centroid of solid material were made. Using the same rating system as previously employed for model sensitivity in the bottom dump analysis, Table 2 was constructed. From Table 2 it can be seen that 13 coefficients were varied. Of the 13, model sensitivity to 11 , for all output considered, was found to be quite low. These 11 are α_1, C_D, β_o $(0 \leq \beta_o \leq 0.6)$, C_m, γ, α_3, α_4, C_D, C_{FRIC} and C_{DRAG}. For the remaining 2 (α_2 and λ) only medium model sensitivity was observed. The Tetra Tech suggested value of 0.3536 for α_2 was obtained from many experiments for 2-D thermals and can be accepted with confidence. Therefore, although the model is sensitive to α_2 large variation of α_2 is not expected and this sensitivity should not be of great concern. Model output is quite insensitive to λ except for the spread of bottom deposits about the centroid where the maximum variation is approximately 15 percent. As in the bottom dump disposal, some attempt to estimate λ for the particular ambient conditions should probably be made. It should be noted that λ is probably the only coefficient encountered in either disposal operation for which model sensitivity (in the case of a dump of extremely fine material that remains in suspension for long periods) would be greater than the sensitivity displayed in this analysis.

TABLE 1. MODEL OUTPUT SENSITIVITY TO BOTTOM DUMP COEFFICIENTS

			Sensitivity to:			
Coefficient	Tetra Tech Value	Coefficient Variation Range	% Solids on Bottom	Distance to Centroid of Bottom Dep.	Spread of Bottom Deposits About Centroid	Comments
α_o	0.235	0.059-0.940	High	High	High	For lack of additional information use Koh's functional form and Tetra Tech value for α_o.
C_D	0.50	0.25-2.0	Medium	Medium	Medium	Since experiments support the hemispherical conceptualization use Tetra Tech value.
C_m	1.0	1.0-1.2	Low	Low	Low	Would always be greater than 1.0 but since sensitivity is low should not cause undue concern.
β_o	0.0	0.0-0.90	Medium $0.0 \leq \beta_o \leq 0.6$	Medium $0.0 \leq \beta_o \leq 0.6$	Medium $0.0 \leq \beta_o \leq 0.6$	Since β_o is probably closer to 0 than 1.0 and sensitivity is low for $0 \leq \beta_o \leq 0.3$ use Tetra Tech value.
α_c	0.001	0.0001-0.01	Low	Low	Low	Use Tetra Tech value.
C_{D_3}	0.10	0.05-0.40	Low	Low	Low	Use Tetra Tech value.
C_{D_4}	1.0	0.50-4.0	Low	Low	Low	Use Tetra Tech value.
γ	0.25	0.10-0.90	Low	Low	Low	Use Tetra Tech value.
C_{DRAG}	1.0	0.50-2.0	High	Medium	High	As Koh indicates, and this analysis illustrates, more experimental study is needed on C_{DRAG}
C_{FRIC}	0.01	0.005-0.04	Low	Low	Low	Use kinematic viscosity of the ambient water.
F_1	0.10	0.01-1.0	Low	Low	Low	Use Tetra Tech value.
FRICTN	0.01	0.001-0.10	Low	Medium	Low	Use Tetra Tech value.
λ	0.001	0.0001-0.01	Low	Low	Low	Should attempt to estimate for particular ambient conditions.

TABLE 2. MODEL OUTPUT SENSITIVITY TO JET DISCHARGE COEFFICIENTS

Coefficient	Tetra Tech Value	Coefficient Variation Range	Sensitivity to: ?	% Solids on Bottom	Distance to Centroid of Bottom Deposits	Spread of Bottom Deposits Amout Centroid	Comments
α_1	0.0806	0.05-0.15	Low	Low	Low	Low	Use Tetra Tech value.
α_2	0.3536	0.15-0.75	Medium	Medium	Medium	Medium	Since α_2 has been experimentally determined, use Tetra Tech value.
C_D	1.3	0.50-3.0	Low	Low	Low	Low	Use Tetra Tech value.
β_o	0.0	0.0-0.90	Low $0 \leq \beta_o \leq 0.6$	Low $0 \leq \beta_o \leq 0.6$	Low $0 \leq \beta_o \leq 0.6$	Low	Since β_o is probably closer to 0 than 1 and sensitivity is low for $0 \leq \beta_o \leq 0.6$, use Tetra Tech value.
C_m	1.0	1.0-1.2	Low	Low	Low	Low	Use Tetra Tech value.
γ	0.25	0.10-0.90	Low	Low	Low	Low	Since results for $\gamma = 0.25$ appear to be average, set $\gamma = 0.25$.
α_3	0.3536	0.15-0.75	Low	Low	Low	Low	Use Tetra Tech value.
α_4	0.001	0.0001-0.01	Low	Low	Low	Low	Use Tetra Tech value.
C_{D_3}	0.20	0.05-0.50	Low	Low	Low	Low	Use Tetra Tech value.
C_{D_4}	2.0	0.50-5.0	Low	Low	Low	Low	Use Tetra Tech value.
C_{DRAG}	1.0	0.25-3.0	Low	Low	Low	Low	Not nearly as sensitive as in the bottom dump disposal.
C_{FRIC}	0.01	0.005-0.03	Low	Low	Low	Low	Use kinematic viscosity of the ambient water.
FRICTN	0.01		Bottom encounter did not occur				Bottom encounter for a jet discharge in a moving ambient is unlikely.
F_1							
λ	0.001	0.001-0.01	Low	Low	Low	Medium	Should attempt to estimate for particular ambient conditions.

Sensitivity study runs were made to assess the accuracy required in the specification of the input data. Values of the ambient velocity, the ambient density, the bulk density of the material being dumped, and the concentration of solids were individually varied by a small amount. In addition, the vertical turbulent diffusion coefficient was varied by an order of magnitude with no resulting model sensitivity observed in either mode of disposal. These runs revealed that a minor variation in the ambient velocity can result in a variation of the computed location of the material. This result was of course expected. It should be pointed out again that the velocity profiles are assumed to be of particular shapes. The error introduced by this approximation is probably greater than any measurement error that might be encountered. As previously noted, the limitation on ambient velocities will be removed in the Tetra Tech modification of the original Koh-Chang model. The investigation of a minor variation in the ambient density indicated essentially no influence upon model output from either disposal operation. Of course if an extremely light material had been dumped, greater model sensitivity to minor variations in the ambient density would probably have been observed.

A slight variation of model output to a minor variation in the bulk density of the disposed material was observed for the case of the bottom dump disposal. However, essentially no variation of output was observed in the case of the jet discharge.

Dredged materials are discharged into tidal waters from pipelines (moving or stationary), hopper dredges, or bottom opening scows. They vary in bulk density and in the settling velocity of their solids. Also, the solids may be consolidated into compactions or cohesive agglomerations, complicating analysis of their behavior. Six general classes of discharges are suggested, based on the method of discharge and on the presence of consolidated sediments. Example computer simulations were performed for several cases for which the necessary information was available.

Since hopper dredge disposal operations last many minutes (are not instantaneous) and have small discharge ports in relation to their volume, they are best modeled using the jet method of discharge. Two methods of representing multiple discharge ports in the model were tested. Model analysis on a single discharge opening was found to be the most appropriate for this purpose. The results from the model can be superimposed to represent the entire discharge.

A hopper dredge discharge case was developed from information on the Columbia River disposal site. A series of computer runs was made in which the input conditions were varied singularly, through ranges which might be encountered. Variations in the settling velocity of the solids had the greatest effect on the model results. A monitoring procedure, often used in the discharge of hopper dredges, was not considered in this case because the effect of adding water on top of the dredged material during a discharge on the behavior of the issuing jet is not known.

Continuous stationary pipeline discharges were not originally intended to be simulated by the Koh-Chang model. A limited amount of information can, however, be obtained by model analysis. The convective descent phase of the model will work for a jet element. The prediction however, will terminate once that element has encountered the bottom or buoyant equilibrium position.

The model was applied to a case of discharge from a bottom opening scow which had been investigated in the field. This discharge was almost instantaneous through multiple bottom openings. The results from the model for the area of the deposited solids were compared to field measurements made after many discharges over the same location. Although no claim of model verification is made, the model results are in reasonable agreement with field observations.

Several methods for handling consolidated sediments are possible, depending on their degree of cohesion. A very cohesive agglomeration might be allowed to descend intact in the model by reducing the entrainment coefficient. Persistent clumps within a slurry could be considered as particles having appropriate settling velocities. Compactions which break down or erode during descent might also occur. More study on the effect of consolidated sediments on the behavior of dredged material discharges is probably necessary.

During the course of the cooperative study, a comparative run was made to compare the output of the model run on a CDC-6400 with one run on a GE-635. The results were identical. The program was originally written on a CDC-7600. It was found that in adopting the program to an IBM-360, double precision was required to prevent limiting round-off error.

SECTION III

CONCLUSIONS

Keeping in mind that particular input conditions were employed throughout this analysis, in general it can be concluded that one does not have to be nearly as concerned about model sensitivity to the many coefficients used by the model or to measurement errors as perhaps initially suspected. The suggested (Tetra Tech) coefficients are adequate in most cases. The bulk density of the dumped material is important to the model results. The convective entrainment function is also very important to the model results but, without further study, use of Koh's smoothing function is suggested.

Minor variation of the ambient density will not influence model output for a dump of fairly dense material. It is doubtful that measurement error in the ambient current is very important since the velocity profiles input to the model are limited to particular shapes and are thus simplifications of actual measurements. The kinematic viscosity of the ambient water can be used for C_{FRIC}. The value of λ should be estimated for the particular ambient environment as this parameter has an important effect on model results for slowly settling solids.

The model can be successfully applied to many types of real dumping situations but does have limitations. The model does not consider any horizontal boundary limits or changes in ambient conditions with time or horizontal position. Stationary jet discharges, such as pipeline discharges, run into computational trouble in the model after convection of the jet but some useful information can still be generated. The model does handle ordinary bottom dump and jet discharges, as it was intended to, and does so for conditions which represent real disposal operations and site conditions. Multiple discharge openings are common. They require that the model be run for a single opening and the results be superimposed to characterize the total deposited patch.

The extent and exact compositions of consolidated sediments which are dumped is not well known. Cohesive material might be encountered in new dredging projects in bays where clays suspended in river water have flocculated in sea water, settled, consolidated and then been mechanically dredged. Non-cohesive compactions can occur in hoppers. Quick settling sand, prompted by vertical loading and vibration, can compact near the bottom of hoppers. Their behavior subsequent to discharge is, at present, a matter of speculation. Generally, highly cohesive spoils are thought to sink to the bottom with little entrainment or dispersion while less cohesive compactions break down during descent. Once their behavior is better understood, schemes available in the model can be applied to enable more accurate computer simulation.

SECTION IV

RECOMMENDATIONS

More experimental study on some of the model coefficients is needed. In the bottom dump discharge method, C_{DRAG} and the entrainment coefficient are important to the model results. The value of C_{DRAG} suggested by Koh is only a rough estimate. Further verification of the functional form of the entrainment coefficient is also needed.

Without further experimentation the suggested values of the coefficients should be used. The assumption of free settling from a cloud is probably closer to reality than the extreme of no settling. Therefore, the value of β_0 should be closer to 0 than to 1.0. For $0 \leq \beta_0 < 0.3$ the model sensitivity can be classified as low and thus setting β_0 equal to the free settling case should not cause undue concern.

The Koh-Chang model, in its original form, can be applied to the physical fate prediction of dredge material discharged into the ocean by several of the methods employed. A model with boundary specifications and time-and-space varying currents is needed for simulations involving the discharge of dredge materials, particularly with slowly settling solids, into estuarine or other restricted tidal areas. The Corps is presently working on a modified version of the model which will be suitable to make predictions in such areas. A model which will handle continuous pipeline discharges is also needed. Confidence in the model output can only come after successful comparison with a variety of typical dredge disposal operations. Studies on the dispersion of dredge materials in the ocean environment are, at present, insufficient to do this.

Detailed field investigations are needed to test the model. Besides the collection of necessary model input conditions and material distribution subsequent to discharge, such field investigations could also attempt to observe and assess factors affecting waste behavior which are not explicitly considered in the model. Allowances or modifications might be possible in the theoretical model. Examples of these factors might be the interactions between multiple jets or instantaneous releases, monitoring procedures, structures incorporated in the discharging mechanism which modify the shape or direction of the released material, vertical density discontinuities within the waste, unsteady or uneven discharge rates, and consolidated sediments within the waste. Other factors probably exist.

SECTION V

DESCRIPTION OF THE KOH-CHANG MODEL

The Koh-Chang model for predicting the short-term fate of wastes, such as dredged material, dumped into an ocean environment, was developed by R. C. Y. Koh and Y. C. Chang while employed by Tetra Tech, Inc. The model development was funded by the Coastal Pollution Branch of EPA's Pacific Northwest Environmental Research Laboratory to use in both monitoring and permit application evaluations.

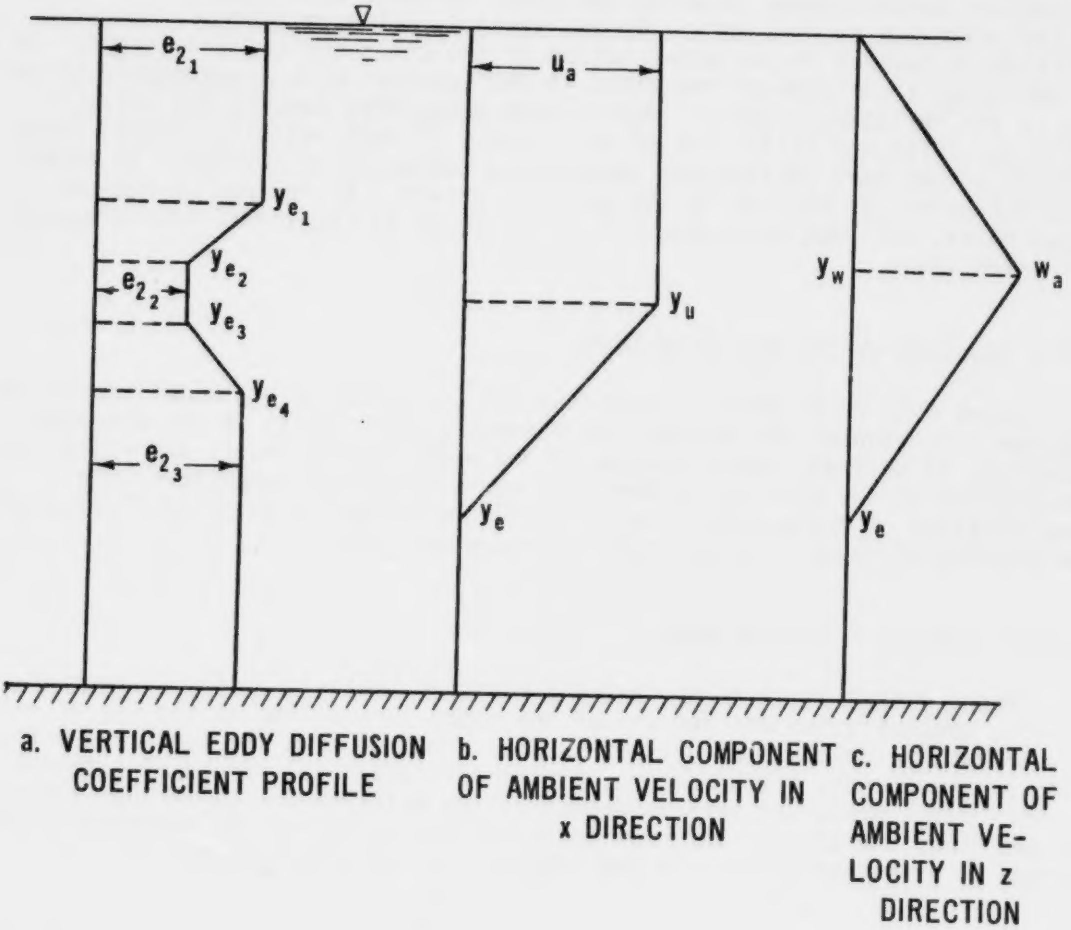
In any attempt to describe the short-term physical fate of an aquatic dump, three major factors must be considered: (a) the disposal method (b) the ambient environment into which the disposal is made and (c) the composition of the material being disposed.

METHODS OF DISPOSAL

The Koh-Chang model allows for three different disposal methods. The first is an instantaneous bottom dump of a three-dimensional slug which is assumed to take the shape of a hemisphere immediately upon entering the water column. The second disposal method is a time-limited continuous discharge through a nozzle under a moving barge. The third method is disposal into the wake of a barge. The wake discharge would probably only be used where high initial dilution is desired.

AMBIENT ENVIRONMENT SPECIFICATION

As illustrated in Figure 1, the Koh-Chang model assumes that the ambient current is composed of only horizontal components of the particular forms shown. Also, the vertical eddy diffusion coefficient profile is assumed to be a variation of a particular shape (Figure 1). The ambient density is considered a function of only the depth, with up to 30 points allowed by the computer program. The assumptions made in representing the ambient environment are chiefly responsible for the original model application being restricted to an ocean-type environment.


e_{2_1}
u_a
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a. VERTICAL EDDY DIFFUSION COEFFICIENT PROFILE
b. HORIZONTAL COMPONENT OF AMBIENT VELOCITY IN x DIRECTION
c. HORIZONTAL COMPONENT OF AMBIENT VELOCITY IN z DIRECTION

Fig. 1 - Representation of Ambient Conditions in Koh-Chang Model

MATERIAL SPECIFICATION

The model allows for the specification of four types of solids with a possibility of two fall velocities being specified for each solid group.

MODEL PHASES

For each disposal option, material is traced through three phases. For a bottom dump these phases are illustrated in Figure 2. The first is a convective descent phase in which the cloud descends as a result of its initial momentum and buoyancy. During descent, either a neutrally buoyant position is reached in the water column or the cloud strikes the bottom. In either case, a collapse of the cloud in the vertical with a subsequent spreading in the horizontal occurs. During both convective descent and collapse, solid particles may settle out of the cloud. If such settling occurs, those particles that have settled are immediately subjected to transport by turbulent diffusion, as well as by the ambient current. At the end of the collapse phase, all remaining material in the cloud is input into the turbulent diffusion phase.

INPUT REQUIRED BY THE KOH-CHANG MODEL

Input data which must be specified for operation of the model consist of the specification of the ambient conditions; a description of the disposed material; if desired, specification of the model coefficients; and a physical description of the disposal method plus various control parameters, e.g., specification of the maximum time of model operation. A detailed listing of the particular input data employed is presented later.

OUTPUT FROM THE KOH-CHANG MODEL

Model output consists of centroid position, velocity, size, volume of solids, concentration and density of the cloud versus time at the end of both the convective descent and collapse phases. Output from the turbulent diffusion phase consists of the amount, centroid location and spread of material in horizontal planes at various depths in the water column at various times. In addition, the amount, centroid location, and spread of the material on the bottom is presented along with the output from the water column.

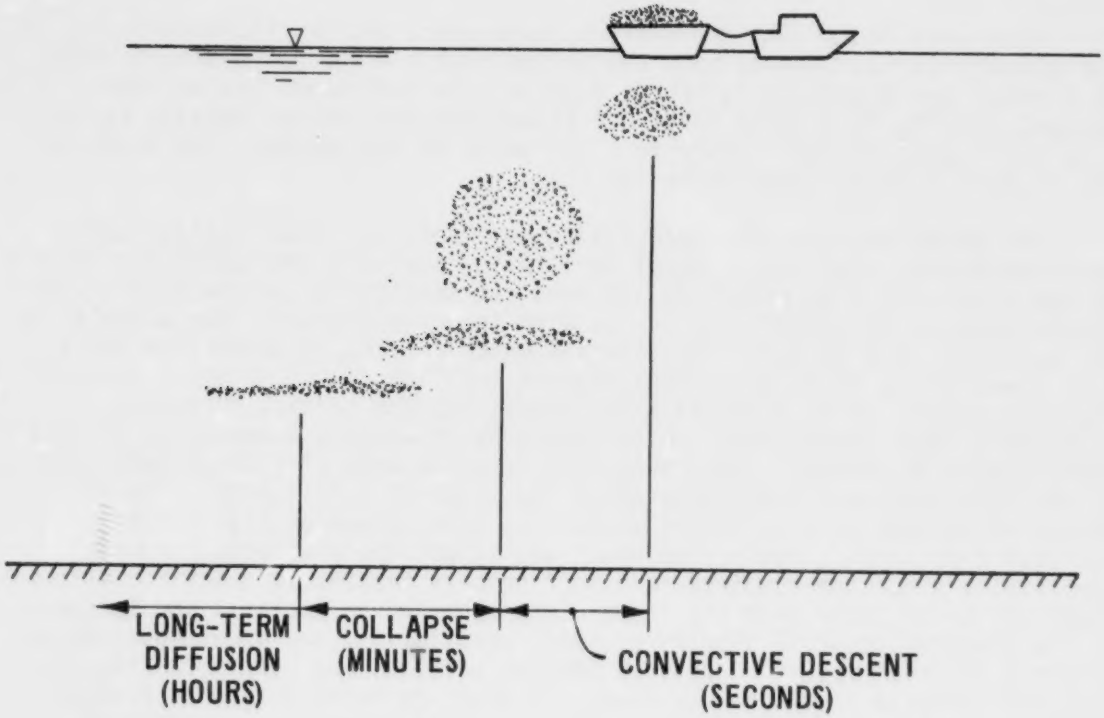
LONG-TERM DIFFUSION (HOURS)
COLLAPSE (MINUTES)
CONVECTIVE DESCENT (SECONDS)

Fig. 2 - Instantaneous Bottom Dump Phases in Koh-Chang Model

SECTION VI

SENSITIVITY OF KOH-CHANG MODEL TO MODEL COEFFICIENTS USING HYPOTHETICAL INPUT DATA

INPUT DATA SELECTED

Input data describing the ambient environment and the characteristics of the dumped material used in both the bottom dump and the jet discharge modes of disposal are presented in Tables 3 and 4. As indicated, the maximum ambient velocity is assumed to be 3.0 ft/sec and the ambient density varies from 1.020 gm/cc at the surface to 1.032 gm/cc at the bottom. The depth of the disposal site is taken to be 150 ft.

The dumped material characteristics were selected after initial model experimentation. For such a model sensitivity analysis, one obviously desires to use input data that result in the greatest sensitivity to the most coefficients since model sensitivity varies with input conditions. For example, in the case of a dump of very fine material which remains in suspension for a long time, the major factors affecting the location of the material are the ambient current, solid material fall velocities, and perhaps turbulent diffusion. Thus, final model output would be relatively independent of most coefficients encountered since their influence is more of a short-term nature. At the other extreme is the case where the material hits the bottom within a matter of seconds as a result of either its density and/or size and/or the disposal site depth. Again, one would not expect the most accurate model sensitivity since the complete transport process happens so quickly. Although there can be no claim that the input data presented in Tables 3 and 4 result in the greatest possible display of model sensitivity, the model does characterize a disposal operation between the two extremes and meaningful results from the analysis should be obtained. It might be noted that most dredged material dumps fall in the category of the second extreme case discussed above.

The remaining input data listed in Tables 3 and 4 relate mainly to the characterization of the disposal method. As indicated in Table 3, the initial radius of the cloud in bottom release disposal is taken to be 10 ft at a depth of 10 ft in the water column. Similarly, from Table 4 it can be seen that in the jet discharge disposal, the radius of the discharge pipe is assumed to be 1 ft and is oriented at an angle of 0° with the vertical, 10 ft below the surface.

TABLE 3. INPUT DATA FOR BOTTOM DUMP DISPOSAL

Ambient Conditions (See Figure 1)

Velocity (ft/sec)	Density (gm/cc)	Vertical Diffusion Coefficient (ft^2/sec)
U_a = 3.0	1.020 at surface	e_{2_1} = 0.0022
W_a = 1.0	1.022 at 30 ft	e_{2_2} = 0.0005
Y_u = 30 ft	1.030 at 45 ft	e_{2_3} = 0.0011
Y_w = 30 ft	1.032 at 150 ft	Y_{e_1} = 30 ft
Y_E = 150 ft		Y_{e_2} = 35 ft
		Y_{e_3} = 40 ft
		Y_{e_4} = 45 ft

Dumped Material Characteristics

Bulk Density = 1.20 gm/cc
Density of Solids = 2.0 gm/cc
Fall Velocity of Solids = 0.05 ft/sec
Concentration of Solids = 20%

Characteristics of Disposal Method

Initial Cloud Radius = 10 ft
Depth of Release = 10 ft
Initial Cloud Velocity = 1.0 ft/sec vertically

TABLE 4. INPUT DATA FOR JET DISCHARGE DISPOSAL

Ambient Conditions (See Figure 1)

Velocity (ft/sec)	Density gm/cc	Vertical Diffusion Coefficient (ft^2/sec)
$U_a = 3.0$	1.020 at surface	$e_{2_1} = 0.0022$
$W_a = 1.0$	1.022 at 30 ft	$e_{2_2} = 0.0005$
$Y_u = 30$ ft	1.030 at 45 ft	$e_{2_3} = 0.0011$
$Y_w = 30$ ft	1.032 at 150 ft	$Y_{e_1} = 30$ ft
$Y_E = 150$ ft		$Y_{e_2} = 35$ ft
		$Y_{e_3} = 40$ ft
		$Y_{e_4} = 45$ ft

Characteristics of Dumped Material

Bulk Density = 1.20 gm/cc
Density of Solids = 2.0 gm/cc
Fall Velocity of Solids = 0.05 ft/sec
Concentrations of Solids = 20%

Characteristics of Disposal Method

Barge Velocity = 2.0 ft/sec at an angle of 180° with the x-axis
Jet Radius = 1.0 ft
Depth of Release = 10.0 ft
Angle of Jet = 0° with the vertical
Discharge Velocity = 5.0 ft/sec
Duration of Discharge = 300 sec

SENSITIVITY TO COEFFICIENTS IN THE INSTANTANEOUS BOTTOM DUMP DISPOSAL

The sensitivity of the model to the various coefficients was determined by individually varying each coefficient. During the test of a particular coefficient, all other coefficients were held constant at the values suggested by Koh. The range of coefficient variation was rather subjectively determined since it was assumed that it would be better to vary each coefficient over a range of values extending past reasonable estimates rather than limit it to one which was too restrictive. A question which arises in such an analysis is, "what output should be compared in order to assess model sensitivity?" For the case of an instantaneous bottom dump of a material possessing the characteristics previously discussed, it was found that the material hit bottom within 30 to 45 seconds and subsequently collapsed. In most cases, 75 percent of the solid material was on the bottom within 5 to 10 minutes and the remainder was deposited within an additional 20 to 25 minutes. For this reason, it was decided that perhaps the most meaningful output to compare in the instantaneous bottom dump disposal was output pertaining to the amount, location and spread of material on the bottom versus time after disposal.

Convective Descent Entrainment Coefficient - α_o

Actually α, which is given by the expression below, rather than α_o is the entrainment coefficient governing entrainment of ambient fluid during convective descent of the hemispherical cloud.

$$\alpha = \alpha_o \left(\tanh \left(B/2\,\pi g C_1 K^2 \alpha_o\right)^2\right)^{1/2}$$

In the above expression, B is the buoyancy and K is vorticity. During the initial descent of the cloud, the vorticity is large which results in α approaching Turner's value of

$$\alpha = B/(2\pi g C_1 K^2)$$

for the entrainment coefficient of a vortex ring. However, as the cloud descends, the vorticity approaches zero and α approaches α_o which is the entrainment coefficient for a turbulent thermal. Experimentally, the value of α_o has been determined at about 0.25. Koh suggests an average value of $\alpha_o = 0.235$. No real justification can be given for the functional form of α other than it does have the proper limits for large and small vorticity and does provide a smooth transition from one to the other.

To determine the influence of the entrainment coefficient upon model output, α_o was varied from 0.059 to 0.940 with, as indicated previously, the Tetra Tech suggested value being 0.235. It should be realized that the range of variation of α_o is much too large. However, it was felt that the results would give some insight into the importance of the convective descent entrainment coefficient.

Plate 1(a)* illustrates a plot of percent solids on the bottom versus time after disposal for different values of α_o. The runs with $\alpha_o = 0.470$ and $\alpha_o = 0.940$ were the only runs during the bottom dump sensitivity analysis in which the cloud reached a neutrally buoyant position in the water column. As a result, Plate 1(a) indicates that the time required for 95 percent of the solids to be on the bottom varies from about 100 sec for $\alpha_o = 0.059$ to well over 2000 sec for $\alpha_o = 0.940$ (computations were made for approximately 2000 sec). Plate 1(b) illustrates that the distance to the centroid of the bottom deposits increases as α_o increases. This of course is because with the larger values of α_o the solid particles remain in the water column longer and thus can be moved greater distances by the ambient current. Plate 1(c), however, illustrates that the standard deviation in the x-direction, which is a measure of the spread about the centroid, isn't as sensitive to variations in α_o.

Convective Descent Drag Coefficient - C_D

As the hemispherical cloud descends through the water column, a drag force is experienced. C_D is the associated drag coefficient which actually is a function of the Reynolds number and thus depends upon variables such as the size and relative velocity of the cloud. However, Koh suggests using a constant value of 0.50 for C_D as obtained from the drag coefficient diagram for a sphere. From Figure 3, it can be seen that for $R_e > 10^3$ C_D varies only slightly from Koh's suggested value of 0.50. To determine extreme effects C_D was varied from 0.25 to 2.0.

From Plate 2(a) it can be seen that the time required for a certain percentage of the solid material to reach bottom increases with increasing C_D. Similarly, plots 2(b) and 2(c) illustrate a substantial degree of model sensitivity to C_D with regard to the centroid location and spread of the bottom deposits.

Settling Coefficient - β_o

The Koh-Chang model contains a settling coefficient β_{ij} which is assumed equal to a constant β_o. Actually, β_{ij} is a function of the ratio of cloud velocity to settling velocity of the (ij)'th solid group, i.e., V/W_{sij}, as well as the concentration. The limits of β_{ij}, and thus β_o, are 0 and 1 where 0 represents free settling and 1 no settling. As Koh reasons, if the velocity of the cloud is zero and the concentration is low, the solid particles will tend to settle freely and hence β_o should be zero. However, if $0<V<W_{sij}$ the value of β_o should range from 0 to 1. For $V>W_{sij}$, even if a particle does

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* All plates are shown in Appendix A.

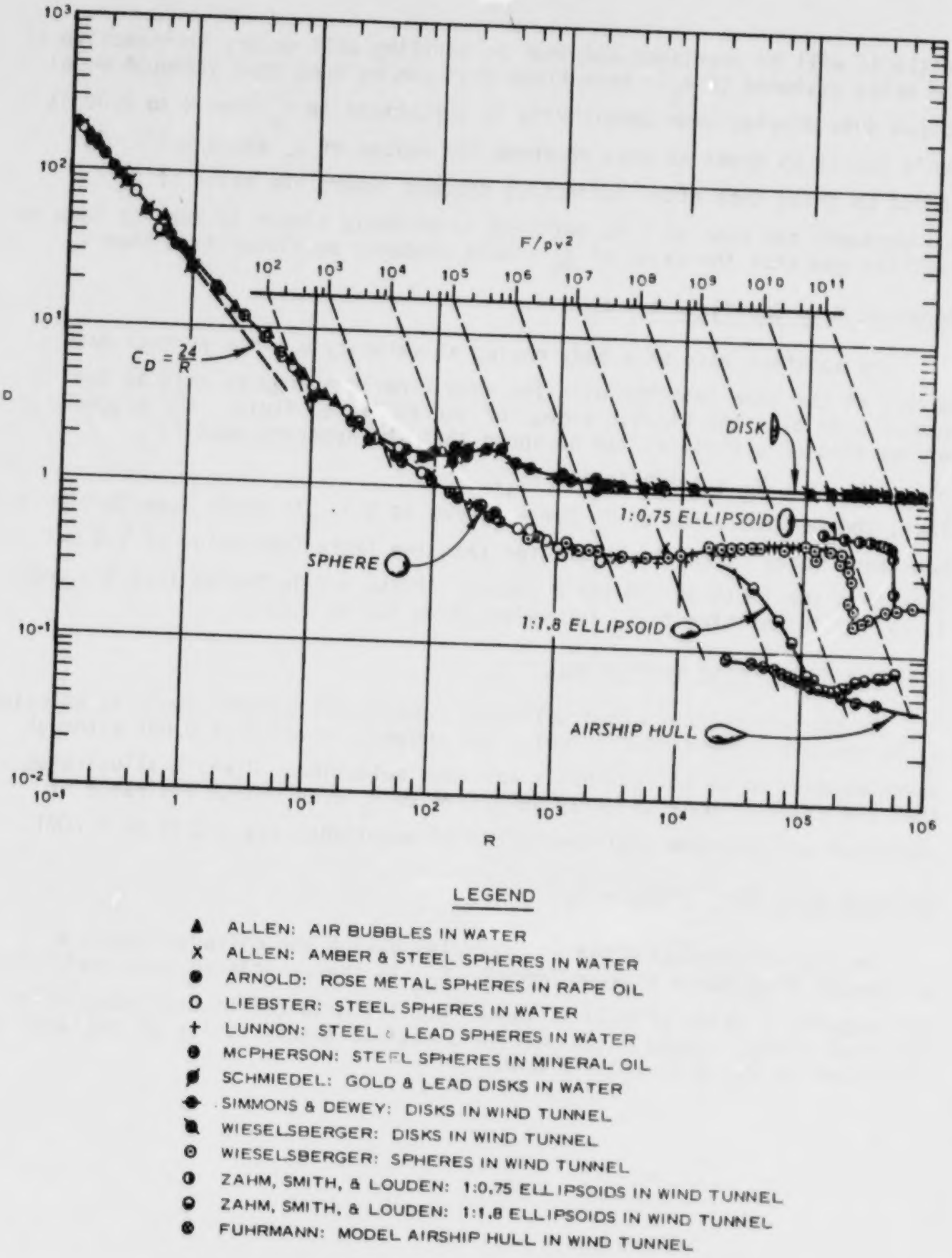


Fig. 3 - Coefficients of Drag for Bodies of Revolution (From Engineering Hydraulics, 1950, by Rouse)

settle it will be overtaken and thus no settling will occur, irrespective of the value assigned to β_o. From Plate 3 it can be seen that although model output does display some sensitivity to variations in β_o from 0 to 0.30 it isn't nearly as great as that observed for values of β_o above 0.30. It should be noted that after convective descent (where the value of β_o is unimportant) the case of free settling is probably closer to reality than no settling and thus the value of β_o should probably be closer to 0 than 1.

Apparent Mass Coefficient - C_m

The apparent mass of a body moving at velocity U_o is a virtual mass moving at the same velocity with the same kinetic energy as that of the actual body plus the kinetic energy of the displaced fluid. For a sphere moving through a fluid it can be shown that the apparent mass is

$$M_a = 4/3\pi R^3(\rho + 1/2\rho_a).$$

Thus, the maximum value of C_m for a sphere is 1.5. It would seem that in the Koh-Chang model C_m should be greater than the Tetra Tech value of 1.0 but less than the limit of 1.5 for a sphere. Plate 4 illustrates that the model is fairly insensitive to C_m for values from 1.0 to 1.2.

Collapse Entrainment Coefficient - α_c

As the ellipsoidal cloud collapses, additional ambient fluid is entrained. α_c is the entrainment coefficient. Koh suggests a value of 0.001 although there appears to be no real basis for this selection. Plate 5 illustrates that the model is only slightly sensitive to α_c even though its range of variation was extended over two orders of magnitude, i.e., 0.01 to 0.0001.

Collapse Drag Coefficient - C_{D_3}

As the ellipsoidal cloud is convected during the collapse phase, a horizontal drag force is experienced. C_{D_3} is the associated drag coefficient. Koh suggests a value of 0.10 as taken from the drag coefficient diagram for a spherical wedge. Plate 6 indicates the extreme insensitivity of the model to variations in C_{D_3} from 0.05 to 0.40.

Collapse Drag Coefficient - C_{D_4}

C_{D_4} is the drag coefficient associated with the drag experienced by the ellipsoidal cloud in the vertical direction and as such is similar to the drag coefficient for a disk with flow directed against it. From Figure 4, it can be seen that the value for such a drag coefficient remains constant at 1.0 for $R_e > 10^3$ and thus is the basis for the Tetra Tech value of 1.0. Plate 7 indicates very little change in model output to values of C_{D_4} ranging from 0.50 to 4.0. This, combined with the fact that sound reasoning lies behind the selection of $C_{D_4} = 1.0$, enables one to use the Tetra Tech value with confidence.

Cloud Gradient Coefficient - γ

The density gradient inside the collapsing cloud is given by

$$\rho^*(Y',R',t) = \rho(1 - \frac{\gamma a_o \varepsilon(y) Y'}{a})$$

where $0 \leq \gamma \leq 1$, $\varepsilon(y)$ is the density gradient of the ambient, and $\gamma\ a_o/a$ is the ratio of the density inside and outside of the cloud. If the density distribution inside the cloud is the same as the ambient environment, i.e., $\gamma = 1$, no collapse occurs. The value suggested by Koh is 0.25. Plate 8 illustrates that for the case of a bottom dump in which material hits the bottom during convective descent no change in model output is observed for values of γ ranging from 0.10 to 0.90.

Collapse Drag Coefficient - C_{DRAG}

Collapse of the cloud is governed by the driving force arising from the difference in the density structure and resistive forces consisting of (1) the inertia force (2) the form drag of the collapsing cloud and (3) the skin friction drag of the cloud. C_{DRAG} is the drag coefficient associated with the form drag and, as Koh notes, is similar to the drag coefficient for a wedge, which results in the suggested value of 1.0. From Plate 9 it can be seen that C_{DRAG} has a significant influence upon model output. For example, Plate 9(a) indicates that 30 minutes are required for 90 percent of the solids to be deposited for $C_{DRAG} = 2.0$; whereas, essentially all solids are on the bottom after 5 minutes with $C_{DRAG} = 0.50$. The reason is probably as follows. As the cloud collapses on the bottom solid particles are deposited. Eventually enough solids are lost and the cloud density becomes less than the ambient and moves up into the water column. With the smaller values of C_{DRAG}, spreading in the horizontal is much more rapid which results in less ascent of the cloud into the water column. Therefore, the solid particles remain closer to the bottom and can be deposited much sooner for small values of C_{DRAG}.

Collapse Skin Friction Coefficient - C_{FRIC}

As previously discussed, the collapsing cloud experiences a resistive skin friction force. C_{FRIC} is the skin friction coefficient and as Koh notes is very similar to the kinematic viscosity of the ambient fluid. The kinematic viscosity of water at 50°F is 0.013 cm^2/sec which is approximately the Tetra Tech suggested value of 0.01. Plate 10 illustrates no change in model output for values of C_{FRIC} ranging from 0.005 to 0.02.

Bottom Encounter Friction Coefficient - F1

The collapse phase which occurs on the bottom is governed by the same equations that govern collapse in the water column except that two additional forces are incorporated. F1 is a coefficient associated with the bed friction force, with the Tetra Tech suggested value being 0.10. Plate 11 illustrates essentially no model dependence upon F1 over a range from 0.01 to 1.0, i.e., two orders of magnitude variation.

Bottom Encounter Friction Coefficient - FRICTN

Similar to F1, FRICTN is also a bottom encounter friction coefficient. Plate 12 illustrates little model sensitivity to values of FRICTN ranging from 0.001 to 0.10, with the value suggested by Koh being 0.01.

Turbulent Diffusion Dissipation Coefficient - λ

In the Koh-Chang model, the horizontal turbulent diffusion coefficient K is assumed to follow a "4/3" law with λ as the associated dissipation coefficient. The Tetra Tech value of λ is 0.001 ft^2/sec. As noted by Okubo and Pritchard (7), values for λ have varied among investigators from 0.0002 to 0.005 ft^2/sec, with the higher values corresponding to a more turbulent or higher energy flow field. Plate 13 illustrates no model dependence upon values of λ ranging from 0.0001 to 0.01. However, it should be remembered that this result is based upon the particular input data employed. For the case of a dump resulting in a collapse of the cloud within the water column, one would expect greater model sensitivity to λ.

SENSITIVITY TO COEFFICIENTS IN THE JET DISCHARGE DISPOSAL

As in the bottom dump disposal, the sensitivity of the model to the many coefficients encountered in the jet discharge mode was determined by individually varying each coefficient while holding all other coefficients constant at the values suggestd by Koh. With the input data previously discussed, dynamic collapse occurred within the water column for all runs. In general, the collapse in the water column resulted in only about 10 percent of the solids being on the bottom after approximately 2000 sec. As a result of the material being in the water column for such a long time, it was felt that ouput related to computations within the water column as well as final bottom deposit results should be compared. Due to the manner in which output is presented by the model, it was then decided that the simplest quantity within the water column to compare was the vertical centroid of the solid material, i.e., $\bar{y}$. Again as in the bottom dump analysis, the range of coefficient variation was rather subjectively set.

Jet Convection Entrainment Coefficient - α_1

The jet convection phase of the jet discharge close to the nozzle is quite similar to the motion of a momentum jet. However, as the jet bends in the direction of the ambient current, the rise or fall of the plume more closely resembles a 2-D thermal. The expression for entrainment of the ambient fluid during the jet convection phase is composed of two parts; namely, entrainment similar to that experienced by a momentum jet and entrainment experienced by a 2-D thermal, with the former dominating in the initial stage of jet convection and the latter in the final stage. α_1 is the entrainment coefficient for a momentum jet and Koh suggests using Abraham's value of 0.0806. Plate 14 illustrates essentially no output variation for α_1 ranging from 0.05 to 0.15.

Jet Convection Entrainment Coefficient - α_2

α_2 is the entrainment coefficient for the 2-D thermal portion of the total jet convection entrainment discussed above. Koh suggests a value of 0.3536 for α_2 as determined experimentally. For values of α_2 ranging from 0.15 to 0.75, Plate 15 demonstrates a substantial degree of model sensitivity.

Jet Convection Drag Coefficient - C_D

In the presence of a cross current, a force arises due to the unbalanced pressure field at the upstream and downstream faces of the jet. A gross drag force perpendicular to the trajectory of the jet was introduced by Koh, with C_D being the associated drag coefficient. Koh suggests a value of 1.3 for C_D as determined from the drag coefficient diagram for a 2-D cylinder. Plate 16 indicates essentially no output variation for values of C_D ranging from 0.5 to 3.0.

Settling Coefficient - β_o

As discussed in the previous section on the analysis of the bottom dump coefficients, the model contains a settling coefficient which is assumed equal to β_o which remains constant. Once again, Koh suggests a value of 0 which represents free settling of the solid particles as opposed to the opposite extreme of no settling, in which case $\beta_o = 1.0$. Plate 17 illustrates model dependence upon β_o. It appears that the model sensitivity is much less for $0 \leq \beta_o \leq 0.6$ than when $0.6 \leq \beta_o \leq 0.9$. As noted previously, the case of free settling is probably much closer to reality than no settling and thus the value of β_o should probably be closer to 0 than 1.

Apparent Mass Coefficient - C_m

The significance of the apparent mass coefficient in fluid mechanics was explained in the previous section. As in the case of a bottom dump disposal, Koh suggests a value of 1.0 for C_m. Plate 18 illustrates essentially no variation of model output for values of C_m ranging to 1.2.

Density Gradient Coefficient - γ

As in the bottom dump analysis, γ is a coefficient governing the density distribution within the cloud. As previously noted, Koh suggests a value of 0.25 for γ, where a value of $\gamma = 1.0$ would result in no collapse. Plate 19 indicates only slight variation in model output for values of γ ranging from 0.10 to 0.90. These plots also illustrate that $\bar{y}$, percent solids on bottom, and $(\sigma_x{}^2)^{1/2}{}_{\text{Bottom}}$ are not monotonic functions of γ on the interval $0 \leq \gamma \leq 0.9$. Note that $\gamma = 0.25$ appears to yield average results.

Collapse Entrainment Coefficient - α_3

During dynamic collapse the cloud is convected by the ambient current while continuing to collapse in the vertical with a subsequent spreading in the horizontal. Entrainment of ambient fluid is accomplished by two mechanisms; namely, entrainment due to convection of the thermal plume and entrainment due to the collapse. α_3 is the entrainment coefficient associated with entrainment as a result of the cloud convection and Koh suggests a value of 0.3536. With α_3 ranging from 0.15 to 0.75, Plate 20 illustrates that model output is quite insensitive to α_3.

Collapse Entrainment Coefficient - α_4

As discussed above, entrainment of the ambient fluid during collapse is accomplished by convection and also as a result of the collapse itself. α_4 is the entrainment coefficient associated with the latter. This coefficient is similar to the α_c encountered in the bottom dump disposal and as before, Koh suggests using a value of 0.001. Plate 21 illustrates very little dependence of the final model results upon α_4, even though α_4 ranges from 0.0001 to 0.01.

Collapse Coefficient - C_{D_3}

C_{D_3} is the drag coefficient associated with the horizontal form drag experienced by the convected collapsing plume. Koh indicates C_{D_3} is similar to the form drag for a 2-D wedge and suggests using a value of 0.20 as taken from the drag coefficient diagram for such a body. For a variation in C_{D_3} from 0.05 to 0.50, Plate 22 indicates no variation in model output.

Collapse Drag Coefficient - C_{D_4}

C_{D_4} is the drag coefficient associated with the form drag experienced by the collapsing plume in the vertical direction. As Koh notes, C_{D_4} is similar to the drag coefficient for a 2-D plate and thus a value of 2.0 is appropriate. As indicated in Plate 23, a variation of C_{D_4} from 0.50 to 5.0 results in no variation of model output.

Collapse Drag Coefficient - C_{DRAG}

As discussed in the bottom dump analysis, collapse is governed by the driving force arising from the difference in the plume and ambient density structure and resistive forces consisting of (a) the plume inertia force (b) the form drag of the collapsing plume and (c) the skin friction drag of the plume. C_{DRAG} is the drag coefficient associated with the resistive form drag of the collapsing plume which is assumed to take the shape of an elliptical cylinder. Koh suggests a value of 1.0 but notes that additional experimental information is needed. Plate 24 (a, b, and c) indicates very little variation of $\bar{y}$, percent solids on bottom and centroid location with C_{DRAG}; whereas, Plate 24(d) illustrates a slightly greater variation of the spread of the bottom deposits for a variation in C_{DRAG} from 0.25 to 3.0. Note that in the jet discharge mode the model does not appear to be nearly as sensitive to C_{DRAG} as in the previous bottom dump of the same material.

Collapse Skin Friction Coefficient - C_{FRIC}

C_{FRIC} is the coefficient associated with the resistive skin friction drag experienced by the collapsing plume. As previously noted, this coefficient is similar to the kinematic viscosity of water and Koh suggests a value of 0.01. As illustrated in Plate 25, model output displays no dependence upon C_{FRIC}. As with C_{DRAG}, the model isn't nearly as sensitive to C_{FRIC} in the bottom dump disposal option.

Turbulent Diffusion Dissipation Coefficient - λ

As previously discussed, λ is the dissipation coefficient associated with the horizontal turbulent diffusion coefficient and is allowed to vary from 0.0001 to 0.01, with the Tetra Tech value being 0.001. Plate 26(a, b, and c) illustrates no dependence of $\bar{y}$, percent solids on bottom and centroid location upon λ. However, Plate 26(d) indicates that the spread about the centroid does exhibit a dependence upon λ.

Bottom Encounter Friction Coefficients - F_1 and FRICTN

For the particular input data employed, bottom encounter never occurred in the jet discharge mode of operation. Therefore, neither F_1 nor FRICTN were investigated since both come into play only when the plume experiences collapse on the bottom.

SENSITIVITY TO A MINOR VARIATION OF THE HYPOTHETICAL INPUT DATA

In the two preceding sections, model sensitivity to the coefficients contained within the Koh-Chang model was investigated. Another important consideration in the application of the model is the question of how accurate the measurements for the required input data must be. To address this question, minor variations in the ambient velocity, ambient density, dumped material density, and solid material concentration were made for both the bottom dump and the jet discharge disposals. In addition, runs were made to determine model sensitivity to the vertical turbulent diffusion coefficient which is considered basic input data.

Referring back to Figure 1, note that the vertical turbulent diffusion coefficient and the ambient velocities are assumed to be of the particular forms shown. As can be seen in Tables 3 and 4, the quantities which must be prescribed for the vertical diffusion coefficient were assumed to have the following values in the coefficient sensitivity analysis:

$$e_{2_1} = 0.0022 \text{ ft}^2/\text{sec}; \; Y_{e_1} = 30 \text{ ft}$$

$$e_{2_2} = 0.0005 \text{ ft}^2/\text{sec}; \; Y_{e_2} = 35 \text{ ft}$$

$$e_{2_3} = 0.0011 \text{ ft}^2/\text{sec}; \; Y_{e_3} = 40 \text{ ft}$$

$$Y_{e_4} = 45 \text{ ft}$$

Similarly, the ambient velocities in Figure 1 were prescribed by

$$U_a = 3.0 \text{ ft/sec}; \; Y_u = 30 \text{ ft}; \; Y_e = 150 \text{ ft}$$

and

$$W_a = 1.0 \text{ ft/sec}; \; Y_w = 30 \text{ ft}$$

whereas, the ambient density was specified to be 1.020 at the surface, 1.022 at 30 ft, 1.030 at 45 ft and 1.032 gm/cc at 150 ft. In addition, from Tables 3 and 4 it can be seen that the dumped material density was taken to be 1.20 gm/cc and the solid concentration was assumed to be 20 percent.

Vertical Turbulent Diffusion Coefficient

To determine the influence of the vertical turbulent diffusion coefficient, the e_2's listed above were increased by an order of magnitude with the corresponding depths remaining the same. For the particular input data previously discussed, Plate 27 indicates no model dependence upon the vertical turbulent or eddy diffusion coefficient in the bottom dump disposal. Similarly, for the jet discharge, Plate 28 illustrates very little model sensitivity.

Ambient Velocity Variation

The effect of a minor variation in the ambient velocity was addressed by increasing the maximum velocity in the x-direction, U_a, from 3.0 ft/sec to 3.3 ft/sec. The only final model output that appeared to be influenced in the bottom dump disposal was the centroid location of the bottom deposits. As illustrated in Plate 29, the maximum variation in this output is approximately 10 percent. For the case of the jet discharge, Plate 30 indicates a similar variation in the distance to the bottom deposits centroid, as well as in the spread of the solid material about the centroid.

Ambient Density Variation

The influence of a small change in the ambient density was determined by changing the four values previously specified by the same amount, i.e., the values of 1.020, 1.022, 1.030, and 1.032 gm/cc were changed to 1.022, 1.024, 1.032 and 1.034 gm/cc. The depths at which these values were specified remained the same. No variation in final model output was observed for the bottom dump disposal and only a very small variation in the spread of the material on the bottom was observed for the jet discharge.

Dumped Material Density - Roo Variation

As previously noted, the density of the material dumped was 1.20 gm/cc in the runs to investigate model sensitivity to the various coefficients. In order to determine the influence of a minor variation in Roo, runs for both the bottom dump and the jet discharge with Roo = 1.22 gm/cc were made. Plate 31 illustrates some final output sensitivity to this small change in the density of material disposed by bottom dump. Therefore, special attention should be given to accurately determining the bulk density of such a dump. However, for the jet discharge of the same material no variation in final model output was determined.

Solids Concentration Variation

To check the influence of a small variation in the concentration of solids, the concentration was changed from 20 percent to 19 percent. No variation in model output was observed for either the bottom dump or the jet discharge disposal of the material.

SECTION VII

APPLICATION OF THE KOH MODEL TO THE DISPOSAL OF DREDGED MATERIALS

PROBLEM OVERVIEW

A typical dredging operation involves loosening bottom sediments, lifting to the surface for temporary storage, and then transporting to an approved dumpsite for final disposal. A variety of equipment can be used. Bucket, clamshell and hydraulic dredges handle the dredged sediments. The final discharge of this material is from barges or scows, hoppers built into dredges, or from pipelines. The manner and conditions under which the dredged materials are discharged are of interest since this information is necessary to correctly characterize the discharge for model evaluation.

Three general conditions exist in most dredged material discharges which need to be considered so that correct input is made to the Koh model. These are in addition to the ambient conditions at the dumpsite and include the type of equipment used, the procedures used in the dumping operation, and the characteristics of the material. As mentioned earlier dredging is done either hydraulically or mechanically. Discharge of dredged material is done by pipeline or sidecaster, bottom opening barges or scows, or by hopper dredges. Hopper dredges are popular and very cost efficient, especially if the distance from the dredging site to the disposal site is small. They typically use hydraulic dredging methods. The dredged material is distributed to the 6 to 10 hoppers (typical) built into each vessel. The hoppers have overflow weirs which, conditions permitting, allow pumping several hopper volumes into the hopper before the settled solids actually fill the hopper. During the discharge operation a relatively small port is opened at the bottom of each hopper and water is often pumped into the hopper to help wash out the spoils. This process is called monitoring. Discharge times vary with the type of dredged material and the characteristics of the vessel. Typically 5 to 15 minutes are required.

Barges, or scows, because of fewer structural constraints and because large volume pumps are not normally installed for surcharged dumping, have larger door openings. Large barges also are subdivided into many hoppers. Discharge times are generally shorter than for hopper dredges.

Pipeline and sidecaster discharges usually take place very near the dredging site in the shallow waters outside of shipping channels. These discharges are continuous to the hydraulic dredging operation. The floating pipeline is stationary while discharging, the sidecaster moves with the dredge.

Since, in the Koh model, there are a variety of ways to characterize the discharge, some details about a discharge under consideration are necessary. The size of the opening, its depth, the average velocity of the material through the opening, the duration of the discharge, and the speed of the vessel during the discharge operation should be known. The rate of surcharging is of interest if hooppers are being monitored during the dump.

Characteristics of the dredged material are, of course, needed for input into the model. The bulk density, solids density and concentration, and settling velocity distribution are needed. Obtaining representative samples in hoppers is very difficult but necessary. In addition to the above information, the physical state of the solids must also be known. The Koh-Chang model normally assumes that the waste material is a slurry and behaves as a liquid, without internal adhesion or density differences. This is not always the case. Sediments can be compacted and exhibit a wide range of cohesion. If the dredged material is made up of a high concentation of fine cohesive particles, agglomeration can occur. Under these conditions the material can pass through the water column intact, without entrainment (6). The waste then takes on a dynamical behavior different from a liquid slurry or different from the individual particles of which it is composed. For a waste to exhibit a high degree of cohesion the excavation method must be mechanical: dipper, clamshell, or bucket dredging. Hydraulic dredging thoroughly mixes and dilutes the sediments with water. Normally an insufficient time for settling is allowed for the clay particles to consolidate and become cohesive. Compaction can also alter the character of the spoils. Even after hydraulic excavation, compaction can take place in the hopper. Vessel motions associated with a seaway and vibration from the vessel's machinery tend to promote compaction. Sediments in a barge are subject to the former but not the latter. If the dredging operation is mechanical then the sediments are likely to be less disturbed and more compact.

From the above ranges of discharge methods and condition, dredged material discharges can be generally classed in six groups for model analysis:

A). Slurry jets lasting many minutes.
B). Slurry jets with some agglomerations.
C). Continuous slurry jet discharges.
D). Instantaneous slurry discharge.
E). Instantaneous slurry release with agglomerations.
F). Instantaneous agglomeration releases.

See Figure 4. Koh-model method 2 is used for the first three, method 1 is used for the analysis of the rest of these cases. These two methods will be discussed in the rest of this paper.

Aside from the input information which is required by the model, it should be stressed that all information on the discharge procedure and dredged material composition should be considered before attempting to characterize a particular discharge. Increasingly complete data, compiled by no small effort of the Corps Districts, is becoming available on the physical and engineering properties of dredged materials.

Direct investigations into the physical behavior of dredged material discharges have not been as numerous as one might expect. One reason is surely the difficulty and expense of these types of field studies. Further investigation of some properties affecting the material's behavior after discharge are needed and would greatly aid computer simulation.

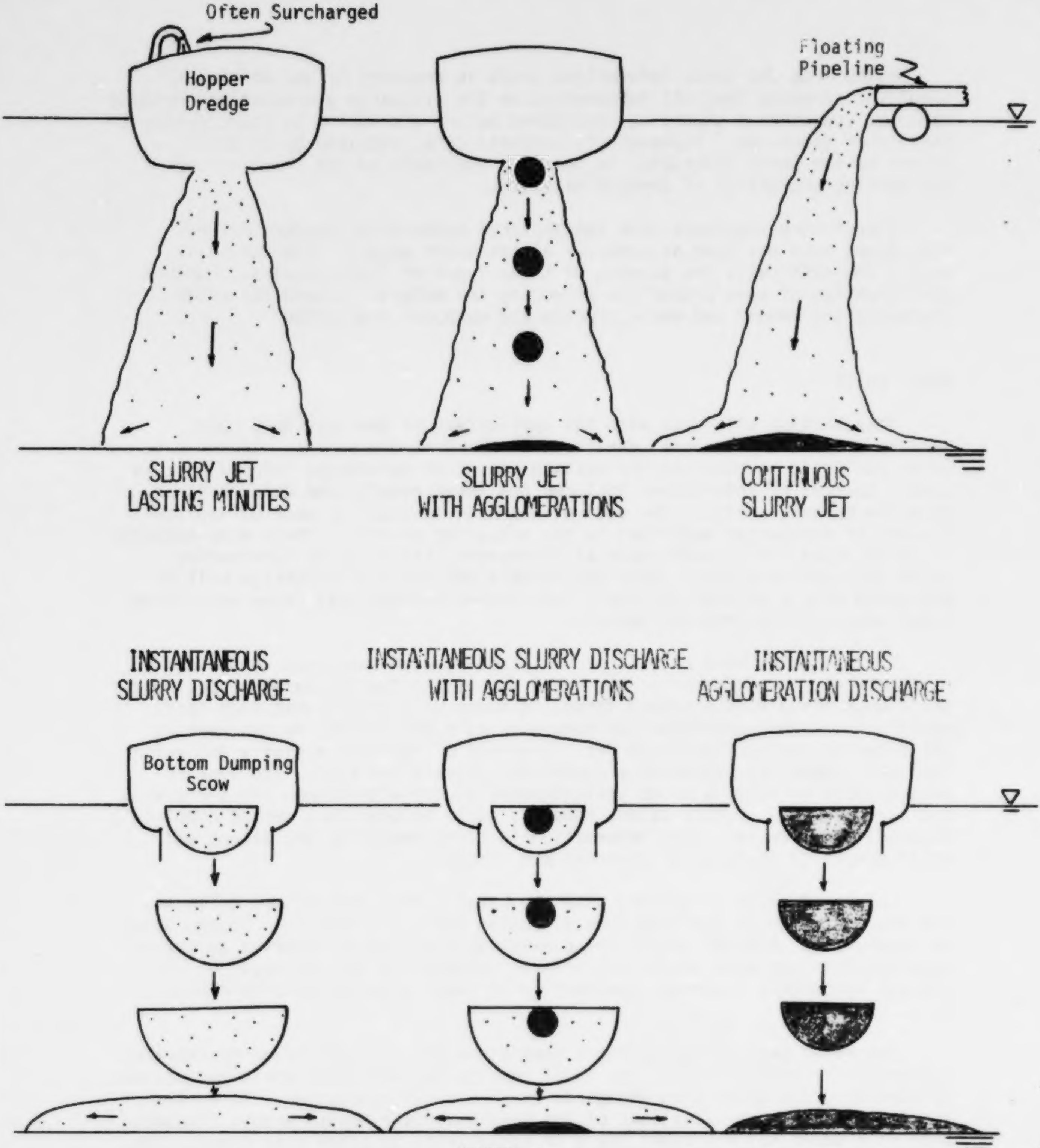
MODEL CASES

This section will deal with the application of the Koh-Chang model methods 1 and 2 to "typical" dredge spoil disposal operations. In order to be as realistic as possible the maximum amount of documented information was used. Sources of information included published reports and data received from the Corps District. The attempt was made to touch on each of the six classes of discharges described in the preceding section. While many examples could be found for certain types of discharges, little or no information could be found on others. Only one example per class of discharge will be discussed with a documented case. Some rather hypothetical cases were formulated where information was sketchy.

Five examples were actually formulated. One of these was completely hypothetical. No information was found describing the discharge of agglomerant clumps mixed with a slurry though it seems very likely that such cases would exist. This condition was suggested as a possibility by engineering personnel in the Portland District. A method of handling a slurry jet which includes clumps was tested on a completely synthesized case. The same approach could be taken with an instantaneous slurry-with-clumps discharge with the same results. Little value, however, could be seen in a second completely hypothetical example. More information is first needed on the extent and exact nature of mixtures of slurries and clumps.

Copies of input conditions used and outputs from convection, collapse, and the last step of the long term diffusion phase are given, as appropriate, in Appendix B. Examination of these examples would be of interest to anyone interested in the more subtle differences between the various types of discharges since only a general description of their behavior will be given here.

The model sensitivity to input parameters was not quantified for several reasons. The reliability of the model results in some cases would be exceeded by operating the model long enough to reach a final conclusion. Also, the sensitivity to input variations of the Columbia River hopper dredge discharge base case would not represent the same sensitivity as other site cases. The sensitivity shown to an individual parameter's variation also depends on the


Often Surcharged
Hopper Dredge
Floating Pipeline
Bottom Dumping Scow

SLURRY JET LASTING MINUTES

SLURRY JET WITH AGGLOMERATIONS

CONTINUOUS SLURRY JET

INSTANTANEOUS SLURRY DISCHARGE

INSTANTANEOUS SLURRY DISCHARGE WITH AGGLOMERATIONS

INSTANTANEOUS AGGLOMERATION DISCHARGE

FIGURE 4

SIX CLASSES OF DISCHARGES TO BE CHARACTERIZED BY THE KOH-CHANG MODEL values of other input parameters. For example if the barge speed is relatively high during discharge, then the discharge time is going to have a larger effect on the results than if the barge speed were low. Many input parameters will be found to vary concurrently in the field. Obviously jet speed and discharge time will vary together for a given jet size and load size. But they might also vary in the field with barge speed, bulk density, and even indirectly with settling velocity. Ambient conditions such as depth of water, density profile, verticle diffusion coefficients and currents will also interact with each other at a given dumpsite. Little would be gained from quantifying the model's sensitivity if the maximum sensitivity to these parameters were not approached. Sensitivity to these parameters can best be tested on a case by case basis. Since the discharge and ambient conditions would never be exactly the same even at the same dumpsite, a complete analysis of a given disposal operation would include the input of a number of cases for which input parameters were determined. This would probably involve a large number of runs. Then any run in which a parameter changed singularly would yield information on the model's sensitivity to it. A run in which certain input parameters changed together would demonstrate that combined effect. Runs to test input uncertanties could then be performed as necessary.

Columbia River Hopper Dredge Discharge

The most typical case of an ocean disposal of dredge spoils is that of a hopper dredge discharge. As mentioned earlier hopper dredges have small discharge openings relative to their hopper volume so that the discharge should be characterized by method 2, a jet lasting many minutes. Responses from Corps Districts indicate that this is the most common discharge method used for ocean disposal, that is disposal outside inland navigable waters.

In a jet discharge simulation (method 2) there are three phases of waste behavior. The jet of given radius, bulk density, initial velocity, and angle with the verticle is injected into the ambient from a barge traveling at a given speed and a given direction relative to the major current component. The first phase of its behavior is convection. The jet descends because of its initial buoyancy and momentum. The second phase occurs either upon reaching buoyant equilibrium with the ambient or encountering the bottom. In either case the waste cloud is spread laterally and compressed vertically. The third phase involves the diffusion and settling of the passive waste.

The disposal operations off the Columbia River in the Pacific Ocean will be used as an example of this class of discharge. Reasonably complete information is available on this dumpsite. It is also currently under intensive investigation by the Corps of Engineers in cooperation with other scientists. Ecological impacts and sedimentology are being studied. This case is also used to test schemes for representing multiple port discharges and the tolerance of the model to changes in input parameters. The changes made were more drastic than those studied in Section VI and are intended to represent the extreme range that's likely to be encountered.

The conditions used to approximate the ambient conditions at the dumpsite are shown graphically in Figure 5. The hopper dredge discharges through 12 openings each 4'9" x 4'3" at a depth of about 23 ft. Discharge time is about 12.5 minutes for a complete 2900 yd^3 load. The spoil material is essentially all fine sand with a solids density of 2.6 gm/cc. Concentration by volume is 30 percent, allowing the bulk density (Roo) to be computed.

$$\mathrm{Roo} = \rho_s X + \rho_l(1-X) = 1.48$$

where ρ_s = Solids density
X = Solids conc. by volume
ρ_l = Liquid density

The bulk density of the dredged material is usually a very important input parameter which is often not reported directly. If the solids density and concentration by weight or volume are known, the density of the liquid phase of the waste can be estimated and the bulk density can be computed. If the concentration of solids is given by weight, then bulk density can be computed as follows:

$$\mathrm{Roo} = \frac{\rho_l \rho_s}{\rho_l Y + \rho_s - \rho_s Y}$$

Y = Conc. by weight

The first problem involved in representing these discharge conditions in the Koh-Chang model is what to do about the 12 openings or 12 jets since only one jet can be simulated in the model. Two possibilities are (a) combine all 12 into one big jet and (b) do the analysis on only one jet and superimpose the results. The former scheme is simpler since, after combining the jet area, the results represent all the discharged material. In doing so, however, the densimetric Froude number (Fn) is being changed.

$$F_n = V_o/(g b_o \Delta\rho/\rho_o)^{1/2}$$

For an individual jet the Froude number is about 0.02; whereas, for a jet whose area is equivalent to all 12 door openings the Froude number is about 0.01. These are both very small Froude numbers but the hydrodynamic similarity might be altered by this scheme. The spacing between these jets is large compared to the radius or the opening so that interactions would probably not occur until deep in the water column.

Koh-Chang model runs were made testing the two schemes for representing the 12 jets involved. The small jet case, representing the discharge through a single hopper, had to be superimposed twelve times in the long term to account for a total barge load. Since the horizontal spacing of the jets was small compared to the horizontal dimensions of the deposited patch, this spacing can be ignored. The total area of the deposited patch was then assumed to be the same as the area resulting from the single small jet. The thickness or accumulation of material indicated within this deposited patch can be multiplied by 12 to arrive at a total.

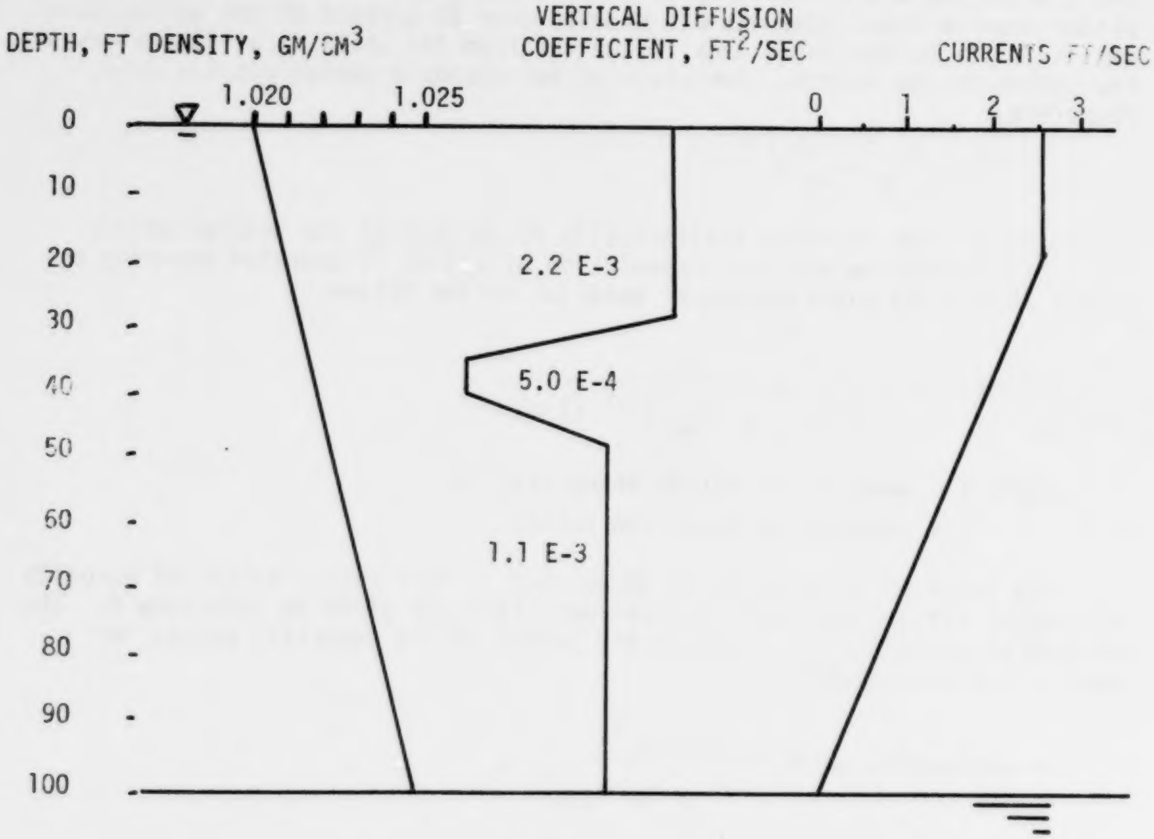


FIGURE 5

SPECIFIED AMBIENT CONDITIONS FOR COLUMBIA RIVER DUMPSITE

To simplify comparison of these results and other runs, the following characteristics are pulled directly or derived from the Koh-Chang model output. During the convective phase of the model, the time required from the beginning of the discharge until the bottom is encountered and the velocity (U) of the jet at this time are listed for comparison. For the collapse phase of the model, the time to the finish of collapse (when spreading due to diffusion is greater than the dynamic spreading of the cloud) and the semi-axis of the cloud at this time are compared. If the cloud collapses on the bottom, it is assumed in the model to be a semi-ellipsoid with its convex side up. Then the semi-axis A and B represent the thickness and radius, respectively. At the end of long term diffusion, the time, bottom patch areas, maximum height and accumulation of solids at the center of the deposited patch, and the percent of the solids settled to the bottom are tabulated. The time at the end of the long term diffusion phase of the model comes either from an input time cut-off or when over 95 percent of the solids have settled. The bottom patch area is derived from the statistical dimensions of the solids on the bottom. Semi-axis of two standard deviations are used. Therefore,

$$4\pi(\sigma_x^2 \sigma_z^2 - \sigma_{xz}^2)^{1/2}$$

describes an area in which statistically 95 percent of the settled solids lie. The maximum height and accumulation of solids is computed assuming a normal (Gaussian) distribution of material on the bottom.

$$\text{Height, ft.} = \frac{W}{2\pi(\sigma_x^2 \sigma_z^2 - \sigma_{xz}^2)^{1/2}\,(1-p)}$$

where W = quantity of solids deposited, ft^3

p = porosity of deposited solids

The porosity is taken to be 50 percent in this case. Values of porosity of freshly settled sediments for various sizes are given in reference 8. The maximum accumulation of solids in the center of the deposited patch, in gm/m^2, is also computed.

$$\text{Accumulation, gm/m}^2 = \frac{6.1E5\ W\ \rho_s}{4\pi(\sigma_x^2 \sigma_z^2 - \sigma_{xz}^2)^{1/2}}$$

The jet radius used for the small jet case was 2.58 ft. For the big jet equivalent to all 12 individual jets it was 8.96 ft. In both cases a jet velocity 0.41 ft/sec was used. A comparison of those output characteristics is listed in Table 5. As the resulting numbers indicate, even though the total material discharged was only 1/12 that of the base case, the area of the deposited patch was almost doubled. The increase in patch area is due to the increased entrainment of the smaller jet.

TABLE 5. COMPARISON OF OUTPOST RESULTS ON THE FINAL DEPOSITED PATCH FOR DIFFERENT MULTIPLE JET REPRESENTATION SCHEMES IN THE KOH-CHANG MODEL

Multiple Jet Representation	Results		
	Area, ft^2	Height, ft	Accumulation, gm/m^2
Combined Large Jet	1.2E6	0.07	2.9E4
Single Jet Superimposed	2.2E6	0.04	1.7E4

Since the model results are significantly changed by combining the jet areas into one large jet, superimposition of the results from a single jet opening is probably necessary for the most realistic representation of multiple jet discharges possible with the model. Conceptually this method is not completely correct since there will be some interactions between the jets after the bottom is encountered, if not sooner. Further investigation of the effects of this on jet behavior and the resultant deposited patch is probably needed. Presumably mutual entrainment between jets would reduce entrainment with the ambient and their interaction while collapsing on the bottom would alter the extent of their spread somewhat.

Certain other input parameters were varied to determine both the sensitivity of the model to those parameters and the tolerances within which the model will execute normally. The input parameters so varied included barge speed, density profile, depth of water, settling velocity of solids, and jet velocity. Jet radius was varied as in the analysis of multiple port representation. Suggested coefficients were used. The output characteristics as previously explained are listed in Tables 6 and 7.

The basic input conditions for the Columbia River hopper dredge discharge are as follows:

Ambient Density Profile	0.0 ft	1.020 gm/cc
	100.0 ft	1.025 gm/cc
Ambient Current Profile	Yu 20 ft	Ye 100 ft
	Ua 2.5 ft/sec	Depth 100 ft

Jet Radius 2.58 ft, Bulk Density 1.48 gm/cc
Jet Velocity 0.134 ft/sec at 13.0 ft depth
Barge Velocity 9.86 ft/sec, Angle with X-axis 180°
Discharge Time 756.5 sec
Density Solids (ρ_s) 2.6 gm/cc
Concentration 30% by Volume
Settling Velocity 0.05 ft/sec

TABLE 6. COLUMBIA RIVER JET CASE WITH VARIATIONS

Model Phase	Convection		Collapse		Long Term Diffusion				
Final Output	T, sec	U, ft/sec	T, sec	AxB ft	T, sec	Area ft^2	Height, ft.	Accum., gm/m^2	% Dep.
Columbia Base Case	97	11.9	1510	2.8x102	2471	2.0E6	0.0012	4.7E2	95
Parameter Varied									
Barge Speed									
= 4.04 ft/sec	96	6.0	1795	3.3x143	2644	8.1E5	0.0031	1.2E3	98.7
= 1.04 ft/sec	92	2.9	2153	3.9x208	3005	4.4E5	0.0057	2.3E3	99.9
Depth									
= 50 ft	89	12.0	1184	1.9x70	1971	8.5E5	0.003	1.2E3	100
Density Profile									
= 1.0245 to 1.0250	62	12.0	268	3.7x32	1048	4.3E5	0.0058	2.3E3	97.7
Jet Velocity									
= 0.01 ft/sec	136	12.4	846	1.6x30	2807	2.0E6	0.00009	3.6E1	96.6
= 0.345(T_{DISCH} = 300)	96	11.7	1878	3.4x157	2264	8.E5	0.0032	1.3E3	98.5
= 0.69(T_{DISCH} = 150)	95	11.5	2160	4.1x314	2408	5.5E5	0.0048	1.9E3	99.8
= 1.0 ft/sec	94	11.4	2338	4.5x252	3188	2.6E6	0.0074	2.9E3	100
= 5.0 ft/sec	37	11.4	127	8x85	1087	1.2E6	0.074	2.9E4	96.6
Settling Velocity									
= 0.001 ft/sec	98	12.0	1420	2.7x95	3502	3.5E7	8E-15	3E-9	1E-10
= 0.005 ft/sec	98	12.0	1420	2.7x95	3823	5E6	2E-10	6E-5	3E-7
= 0.5 ft/sec	61	12.1	1045	2.1x55	COMPLETE*				
= 1.0 ft/sec	32	12.2	563	1.3x18	COMPLETE*				

---

*All solids settled in collapse.

TABLE 7. BIG JET CASE WITH VARIATIONS

Model Phase	Convection		Collapse		Long Term Diffusion				
Final Output	T, sec	U, ft/sec	T, sec	AxB ft	T, sec	Area, ft^2	Height ft	Accum., gm/m^2	%Dep.
Big Jet Base Case	38	11.4	125	8.1x84	1089	1.2E6	0.07	2.9E4	96
Parameter Varied									
Barge Speed									
= 7.04 ft/sec	33	8.7	FAILED						
= 4.04 ft/sec	25	6.1	FAILED						
= 1.04 ft/sec	14	5.5	FAILED						
Depth									
= 75 ft	24	11.8	247	7.2x45	1100	8E5	0.11	4.4E4	96
= 50 ft	12	12.2	FAILED						
Density Profile									
= 1.022 to 1.025	38	11.4	227	6.5x105	1121	1.3E6	0.066	2E4	96
= 1.023 to 1.025	37	11.4	416	9.7x68	1297	1.1E6	0.078	3E4	96
= 1.0245 to 1.025	36	11.4	FAILED						
Jet Velocity									
= 0.134 ft/sec	98	11.2	2546	5.1x306	FAILED				
= 0.27 ft/sec	49	11.3	1853	3.1x235	2685	2.7E6	0.022	9E3	100
= 1.0 ft/sec	24	11.6	339	11.5x54	1314	1.0E5	0.21	8E4	96
= 5.0 ft/sec	11	13.0	FAILED						
Settling Velocity									
= 0.001 ft/sec	38	11.4	190	6.2x111	FAILED				
= 0.005 ft/sec	38	11.4	190	6.2x111	FAILED				
= 0.5 ft/sec	38	11.4	1784	3x239	COMPLETE*				
= 1.0 ft/sec	38	11.4	1820	3x235	COMPLETE*				

*All solids settled in collapse.

Suggested coefficients were used. Then holding all other parameters at these values, the individual parameters under consideration were varied. These results are given in Table 6. Even though the range of input parameters used was meant to cover values normally encountered in open-ocean disposal sites and that which would be expected to result in meaningful output, they were not varied sufficiently to truly test the model's tolerance. There were no unexplained terminations during any of these model runs. The cases in which the settling velocity was increased terminated before the long term diffusion phase but the reason for this was simply that there were no solids left in suspension after collapse to perform these computations. The size of the deposited patch can be derived easily from the results of collapse. The results are therefore complete without the long term diffusion phase. The jet velocity parameter was varied in this analysis with and without an appropriate change in the discharge time. The results from those cases in which only the jet velocity was changed are not directly comparable in the characteristics of the deposited patch since the total quantity of material discharged varies directly with the jet velocity. Those cases in which both jet velocity and discharge time are varied concurrently represent the predicted effect of changing these parameters in the field. Some of the output from the Columbia River base case is reproduced in Section 1 of Appendix B.

Considering the range of values which are likely to be encountered, variations in settling velocity will cause the widest range in output characteristics. The time cut-off for runs with low settling velocities was not long enough to allow an adequate amount of material to settle out of the water column to be representative of the resulting deposited patch. A problem which will likely be encountered in running the model in its present state for low settling solids is that the ambient current structure is fixed with time. This would cause significant errors if dispersion in the presence of tidal current is carried out over many hours. An up-graded version of the model which will handle such time dependencies is being developed by the Corps of Engineers Dredged Material Research Program.

A second set of runs was performed about a base case which combined the area of the 12 jet openings of the Columbia case into one large jet. This case will be called the big jet case hereafter and differs from the Columbia base case in the following input parameters:

Jet Radius	8.96 ft
Jet Velocity	0.41 ft/sec

The cases run for the big jet were less tolerant of variations in input conditions. Besides cases in which all the solids settle out before the long term diffusion phase began, a number of runs failed before getting into the collapse phase or failed to finish collapse completely. The basic problem in these runs is that the model is unable to select a time step for the collapse phase which will meet the model's necessary criteria. In the big jet cases, the convecting jet entrains less and thus reaches the bottom with a sizeable density difference with the ambient. The cloud is then supposed to collapse until spreading by diffusion is greater than dynamic collapse. The entrainment during this phase is low and if the settling velocity of the solids is not sufficient to remove solids from the cloud, dynamic collapse requires a significant amount of physical time relative to convection. If the model cannot select a time step to complete collapse within 600 steps it in effect gives up.

The time step problem will not normally be encountered. No jet-type discharges with a jet area of 250 ft^2 as in the big jet case have been found. Few hopper dredges were found to have discharge openings much larger than the Columbia River case. The model seems to be quite tolerant to variations in barge velocity, jet velocity, settling velocity, depth and density gradient for a jet size which would normally be encountered.

As previously mentioned, hopper dredges often surcharge the hoppers during discharge in a process called monitoring. Water is usually pumped through the same pumps and manifolding used in the excavation process. This both speeds the discharge and makes it more complete. This procedure was not considered in the Columbia River case. Since a volume of water equal to 25 percent of the hopper may be added during the discharge operation, it should somehow be included in the model analysis of that discharge. The simplest approach would be to add the known volume of water to the hopper for the computation of bulk density, volume of waste, concentration of solids and jet velocity and input these adjusted values into the model.

Blake Island Pipeline Discharge

A simulation of a pipeline discharge was done using data on a pipeline discharge 2700 feet east of Blake Island in Puget Sound, Washington. The discharge involved a 16 inch diameter pipe which is oriented horizontally 20 feet below the surface. The discharge is composed of a non-cohesive mixture of granules, sand, and silt, assumed to have a total concentration of 20 percent by volume. The discharge is atypical of pipeline discharges in that it is in 240 feet of water. The jet velocity was computed by dividing the volume discharged per unit time by the jet area. Since a continuous discharge is impossible to simulate in the model, a discharge time of 20 minutes was inputted. Discharge method 2 is used in the model. Some of the output from this case is reproduced in Section 2 of Appendix B.

The problem with simulating a pipeline discharge was found to be that the model will not run past convection without a barge velocity. This is a problem since a discharge of this type is normally stationary. A barge velocity of 0.01 ft/sec was initially input and increased to 1.0 ft/sec before the model would run past the convection phase. A barge velocity this high would seriously effect the bottom encounter computations and thus the characteristics of the deposited patch.

Even though the collapse and long term diffusion phases can't be accurately simulated for this case, output from the convection phase can be very valuable. Though only a partial solution to the problem of the behavior of the waste, characteristics of the convecting jet can yield potentially useful information for many cases. Questions on the depth of penetration of the jet into a density-stratified water column, and the speed, size, and concentration of the jet at bottom encounter could be answered. Such information can certainly be valuable as a basis for assessing some aspects of ecological impact.

New Haven Instantaneous Bottom Dump

Method 1 simulates a dump as an instantaneous release of a hemispherical cloud of a given radius, bulk density and initial velocity. The hemisphere retains its identity as it descends by buoyancy and momentum forces. Entrainment during convection is proportional to the clouds velocity relative to the surrounding water and its vorticity. The model will allow the settling of solids out of the cloud depending on the situation.

In applying this method to the types of releases which really occur, some kind of simplification of the real dump usually must be made. Typical barges involved in instantaneous releases often have openings and initial shapes far different from a hemisphere. Multiple ports again are common and could be handled in the model either by combining all discharges into one large hemisphere or by treating the discharge of an individual hopper separately and superimposing the results. The later is more realistic if the spacing of the openings is significant. The shape of the discharge opening may affect the real vorticity generated. The Koh-Chang model could be altered to change the vorticity initially generated and its decay as these phenomena become better understood. The way in which solids settle out of the cloud during convection is also a complicated problem which deserves more study.

An example of an instantaneous slurry discharge might be that of the barge New Haven. A rather thorough examination of the dispersion of dredged material dumped from this barge at the disposal site in Long Island Sound, off New Haven, Conn., was made by Gordon (9). His descriptions were supplemented by information supplied by the U.S. Army Engineer District, New York. The barge involved is a bottom opening scow with 8 hoppers, each with an opening of 20 ft x 5 ft. The total capacity of the barge is 2000 yd^3. Gordon considered the discharge a jet and calculated its initial velocity at between 2 and 5 meters per second. Since with these discharge openings and initial velocities the hopper discharge only requires a matter of seconds, the discharge will be considered instantaneous here.

The bulk density of the waste in this case is assumed 1.48 gm/cc, with a solids concentration of 29 percent by volume and a solids density of 2.65 gm/cc. The material consists of non-cohesive particles of silt and clay size. For this analysis a settling velocity of 0.01 ft/sec was assumed. Depth of water at the disposal site is about 70 feet. A constantly-decreasing density structure was assumed, varying from 1.018 gm/cc at the surface to 1.020 gm/cc at the bottom.

For the computer simulation of this instantaneous release, two initial cloud sizes where selected equivalent in volume to one-third of a hopper and one-third of a barge load. This initial size is arbitrary and based only on a feeling that much less than an entire barge load, and probably less than a hopper full, could be released instantaneously.

Runs were performed for the two radii and the two initial velocities. These initial runs all required 599 steps in collapse and although the collapse phase was printed out, it never really reached the end of collapse. The selection of a time step for the collapse phase of method 1 (instantaneous bottom dump) is different from that used in method 2 (jet). In method 1, the value of DINCR2 is used to modify dT_1 on successive attempts to select a time step for the collapse phase. dT_1, the time step used in convection, is used as the first trial time step in collapse. If there is to be a large difference between dT_1 and the final time step selected for collapse, the modifier, DINCR2, might have to be increased from its normal value of 1.0. This is different from the procedure used in method 2 in which DINCR2 is used as the initial time step for collapse and then modifies it if necessary. In method 1, DINCR2 might have to be increased even though the time step finally selected might be less than 1.0!

The value of DINCR2 was increased from 1.0 to 5.0 and all runs executed normally. Some of the output characteristics of these runs are listed in the Table 8 which follows. Convection and collapse are the only two phases considered since almost all the solids are deposited within this period. Some of the output from this case is reproduced in Section 3 of Appendix B.

TABLE 8. PREDICTED NEW HAVEN BOTTOM DUMP CHARACTERISTICS

Input Conditions		Output Characteristics			
Radius of Cloud, ft	Initial Velocity, ft/sec	At Bottom Velocity	Encounter-Radius	Patch Radius- 82% Removed	Final
10.24	6.0	5.5	24.6	517	738
10.24	16.5	5.6	24.6	519	742
20.48	6.0	11.2	33.9	1524	2356
20.48	16.5	11.5	34.0	1535	2377

From the table it becomes apparent that the initial velocity of the waste cloud had little effect on its behavior. The initial size did have considerable effect. The large hemisphere increased the bottom area affected by 9 times over the small hemisphere analysis. Gordon's analysis of the New Haven dumpsite included a survey of the bottom deposit resulting from a large number of discharges. The position of the discharges was consistent. This survey indicated that most of the material was deposited within a radius of 558 feet and essentially all settled within 656 feet. The results from the small discharge are in very good agreement with these dimensions. Results from the analysis of a small hopper put 82 percent of the solids within 519 feet and all solids deposited within a 742 foot patch. The model has rather low sensitivity to most of the parameters which had to be assumed, settling velocity of the solids having probably the greatest influence on the results. It is very encouraging that a dredged material discharge can be simulated with the Koh model and results so closely approximate field observation. However, studies of the short term behavior of dredge spoil discharges such as the one done by Gordon are very scarce and greater detail is needed for actual verification. Much more field evaluation data must become available before real-world confidence in the Koh-Chang model can be achieved.

Discharges Involving Agglomerated Sediments

Discharges, either instantaneous or jet, involving compact and/or cohesive agglomerations need more investigation before they can be accurately modeled. Presumably those clumps or combinations of clumps and slurries would have entrainment rates and settling characteristics different from ordinary slurries. Two extreme types of clumps can be envisioned, depending on their cohesiveness. A clump of sand without much cohesiveness might disintegrate quickly while falling through water. Cohesive clay on the other hand might fall through water almost intact. Assuming that agglomerations behave in this way, cohesive clumps would be the easiest to deal with. The persistence of non-cohesive clumps would be difficult to determine. Output from the convection phase of the model might be helpful in estimating their speed relative to their surroundings. Given the clump's size and density and the characteristics of the convecting jet from the model, the buoyant forces of the clump relative to the jet plume could be analyzed and its sinking rate within the jet estimated. Then if erosion rates (mass/ area/time) as a function of relative velocity were known, one could guess at the longevity of the clump. The information needed on the clumps would not be easily obtained, however, since the sampling of these things alone would be a major obstacle.

To simulate a dump of cohesive material in the model the entrainment coefficient used for convection could be greatly reduced to allow the spoils to fall almost intact. A hypothetical example was formulated very generally from Saila _et al._ (10). Very little information detailed was supplied in that reference and much input had to be assumed. The hypothetical instantaneous discharge considered consists of 2000 yd^3 of cohesive sediments dumped into 100 feet of water. For this run the entrainment coefficient, alpha, was decreased from 0.235 to 0.01 and the settling coefficient, beta, changed from 0.0 (free settling) to 1.0 (no settling). The resulting model run depicted a hemispherical vortex cloud which descended almost unchanged, encountered the bottom and collapsed very completely. The radius of the deposited patch was only 107 feet. Some of the output from this case is reproduced in Section 4 of Appendix B.

As mentioned above, accurate simulation of the discharge of a non-cohesive clump would depend on some knowledge of the persistence of these clumps during descent. It seems likely that the behavior of a non-cohesive clump would be similar to that of a slurry after a short initial period of lower entrainment.

Agglomerations mixed with slurries could be handled differently. Again depending on the longevity of the clumps, the overall density and settling velocity of the clumps could be specified as solid's characteristics. The concentration used for this clump fraction would be the volume concentration of the clumps in the slurry. In this way the liquid portion of the clump would be treated as part of a solid in the model. This would result in the clump fraction being quickly deposited. The area in which this occurs could be easily seen in the output for the collapse phase. This method was used for a hypothetical case and seemed to work well for clumps with settling velocities of 0.9 ft/sec. Output from this hypothetical case appears in Section 5 of Appendix B.

SECTION VIII

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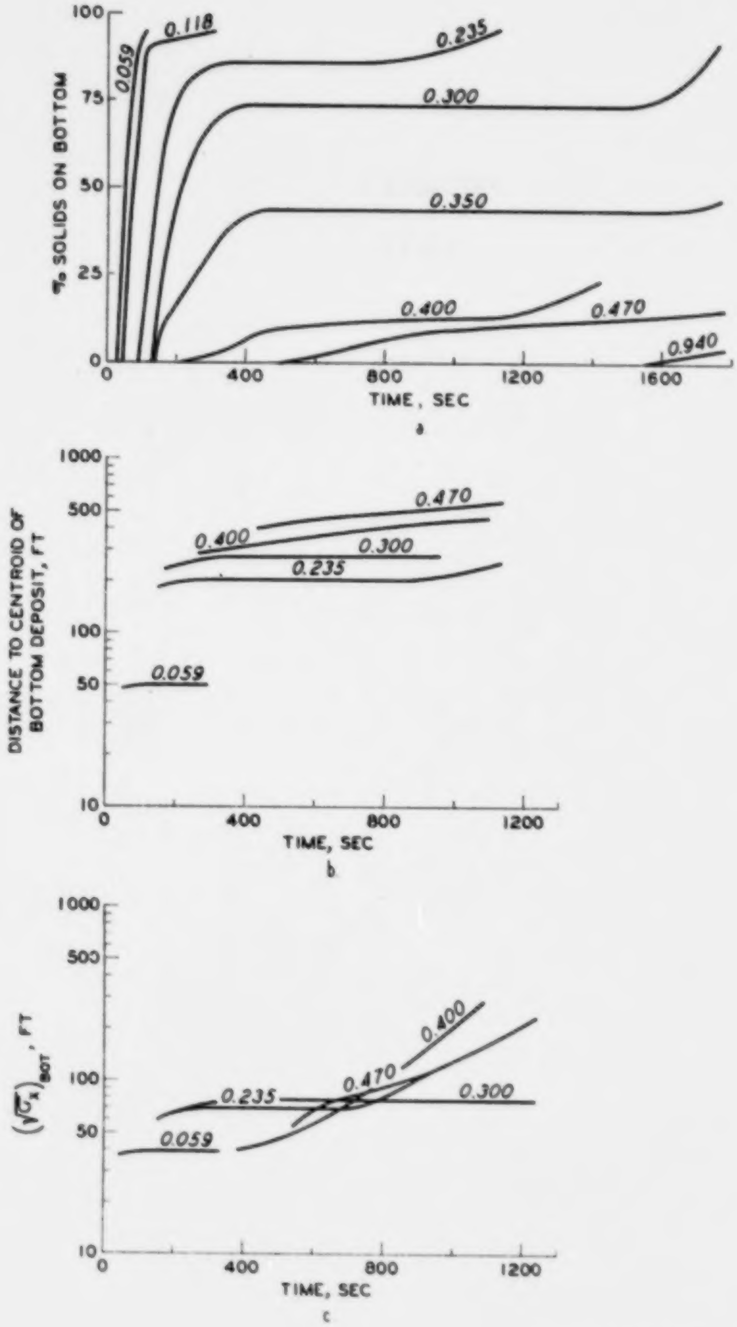
APPENDIX A

PLATES



SENSITIVITY OF
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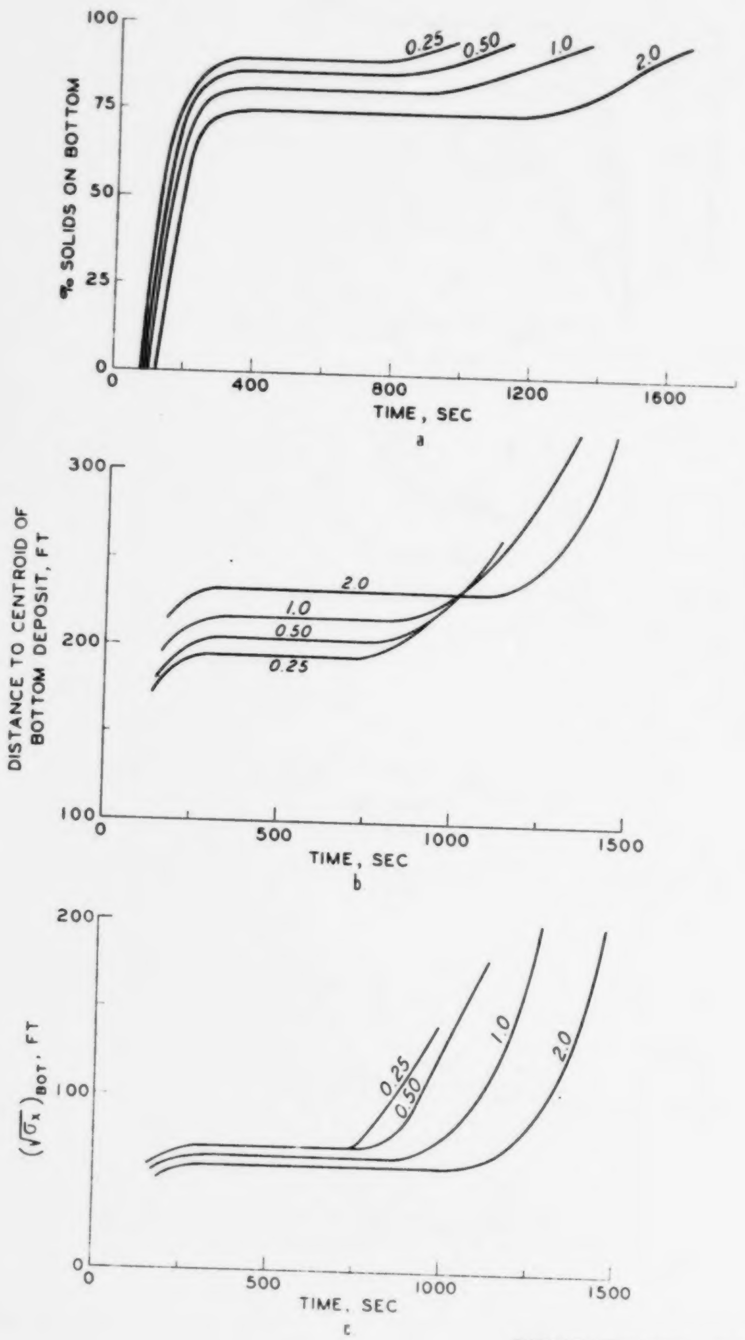
IN BOTTOM DUMP DISPOSAL



SENSITIVITY OF
MODEL OUTPUT TO C_D
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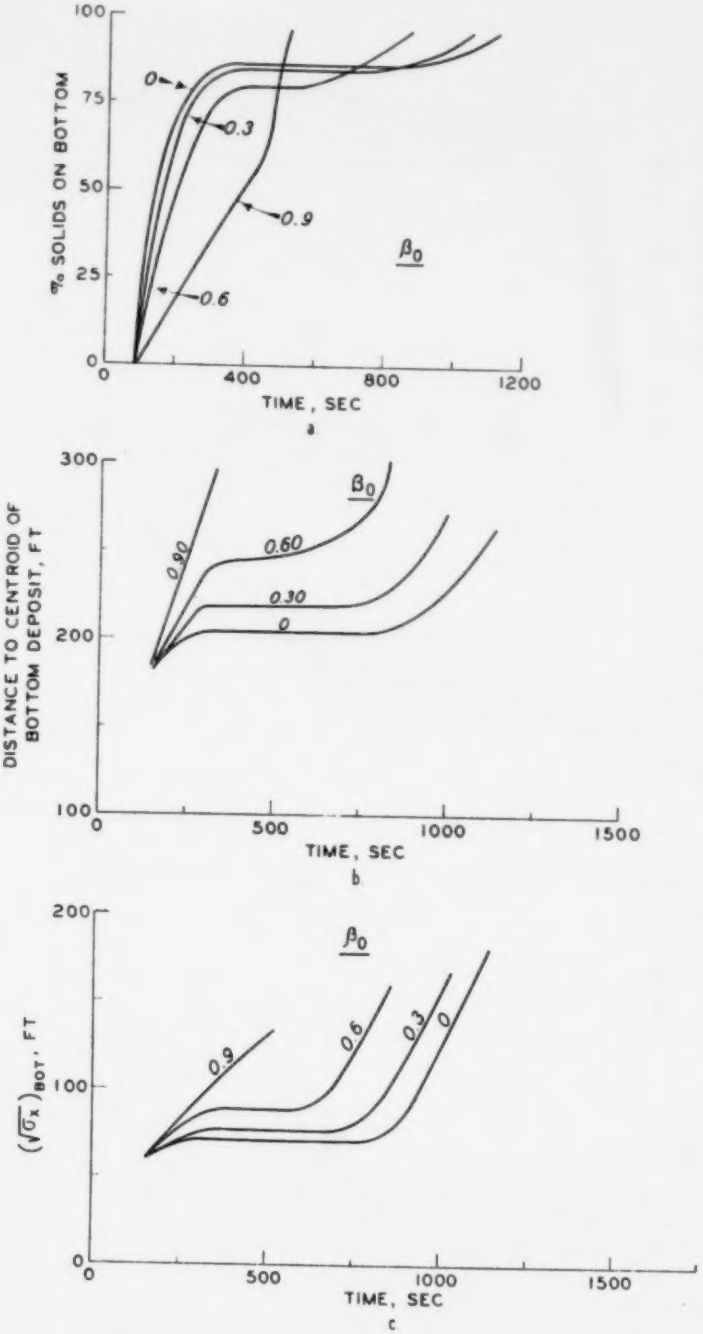
PLATE 2



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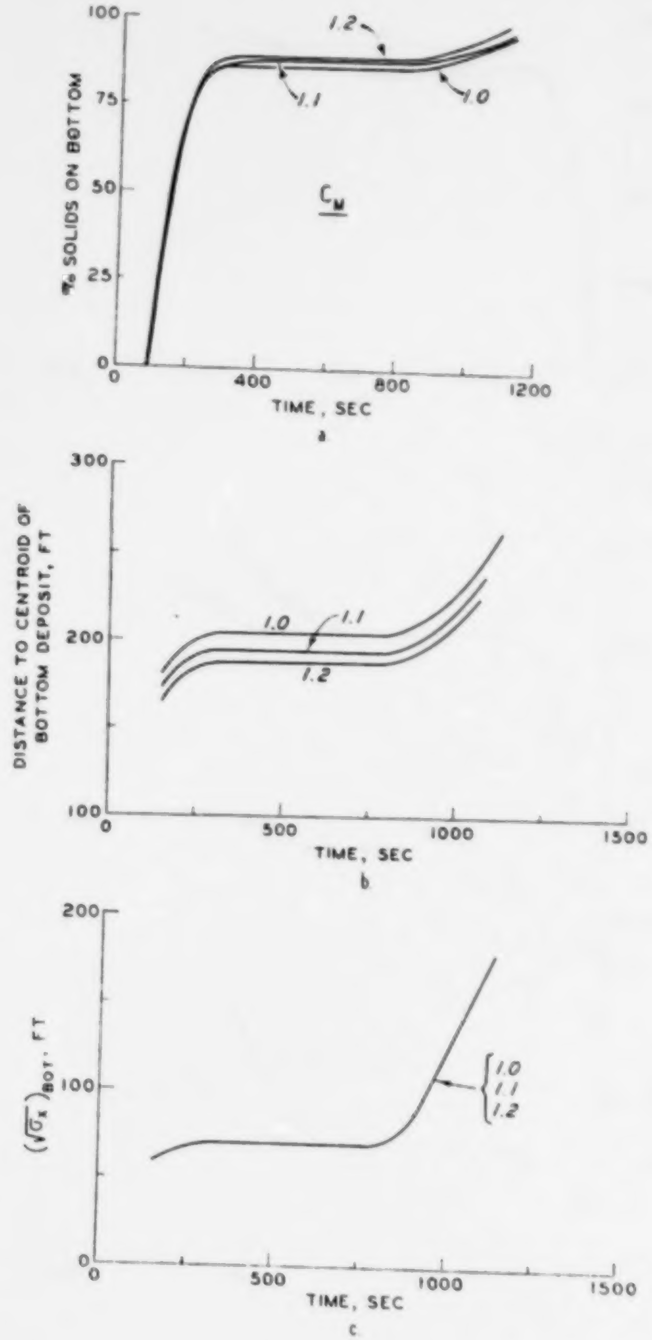
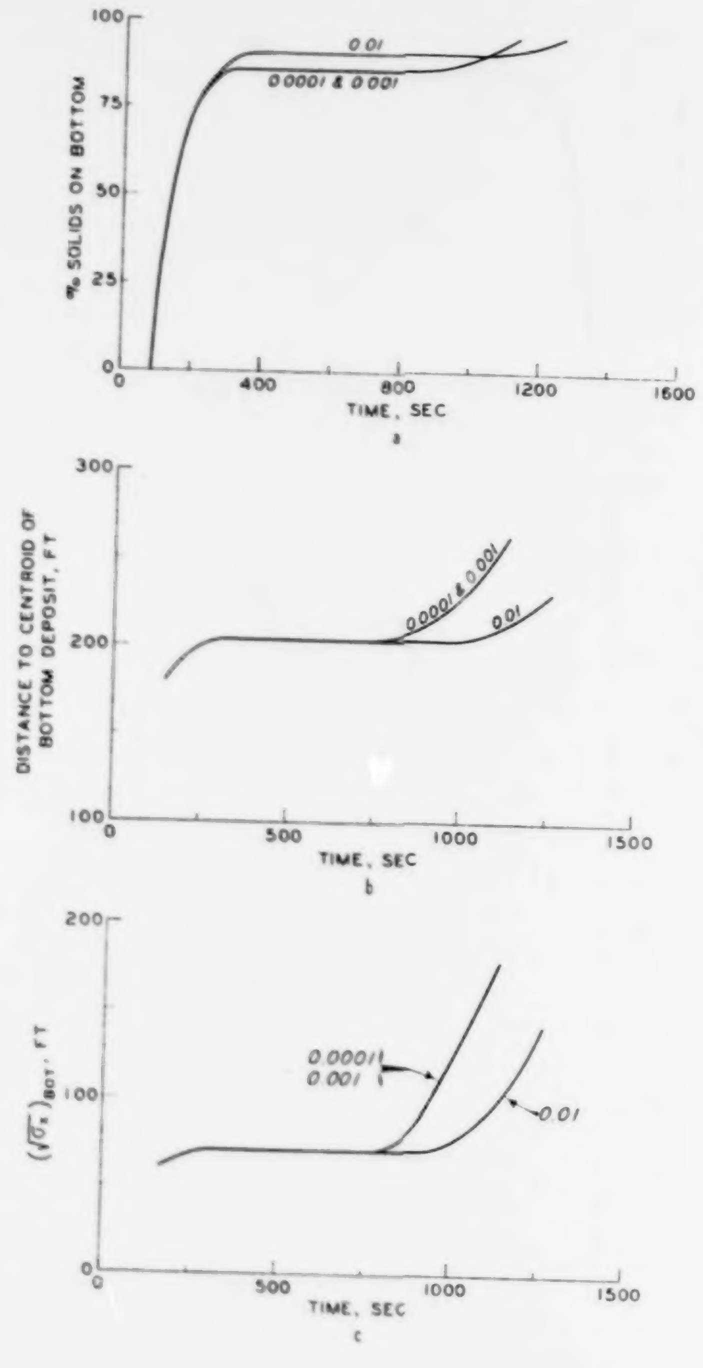


SENSITIVITY OF MODEL OUTPUT TO C_M IN BOTTOM DUMP DISPOSAL



SENSITIVITY OF
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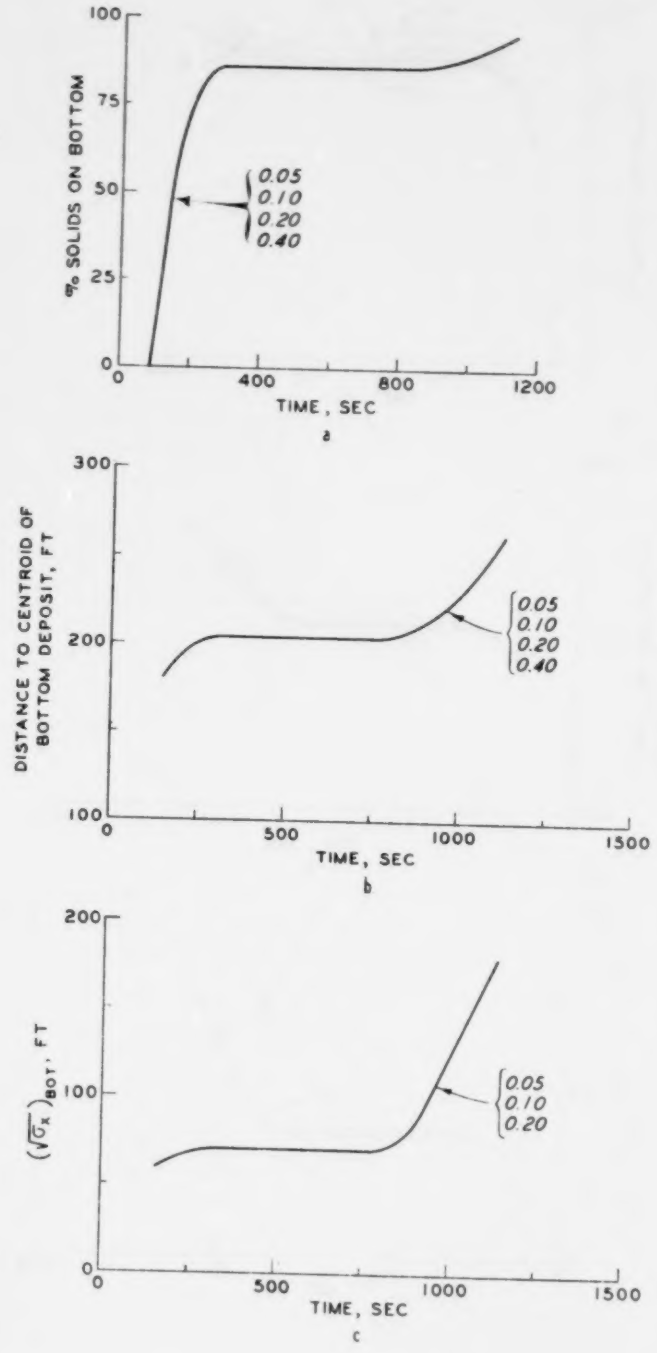

SENSITIVITY OF
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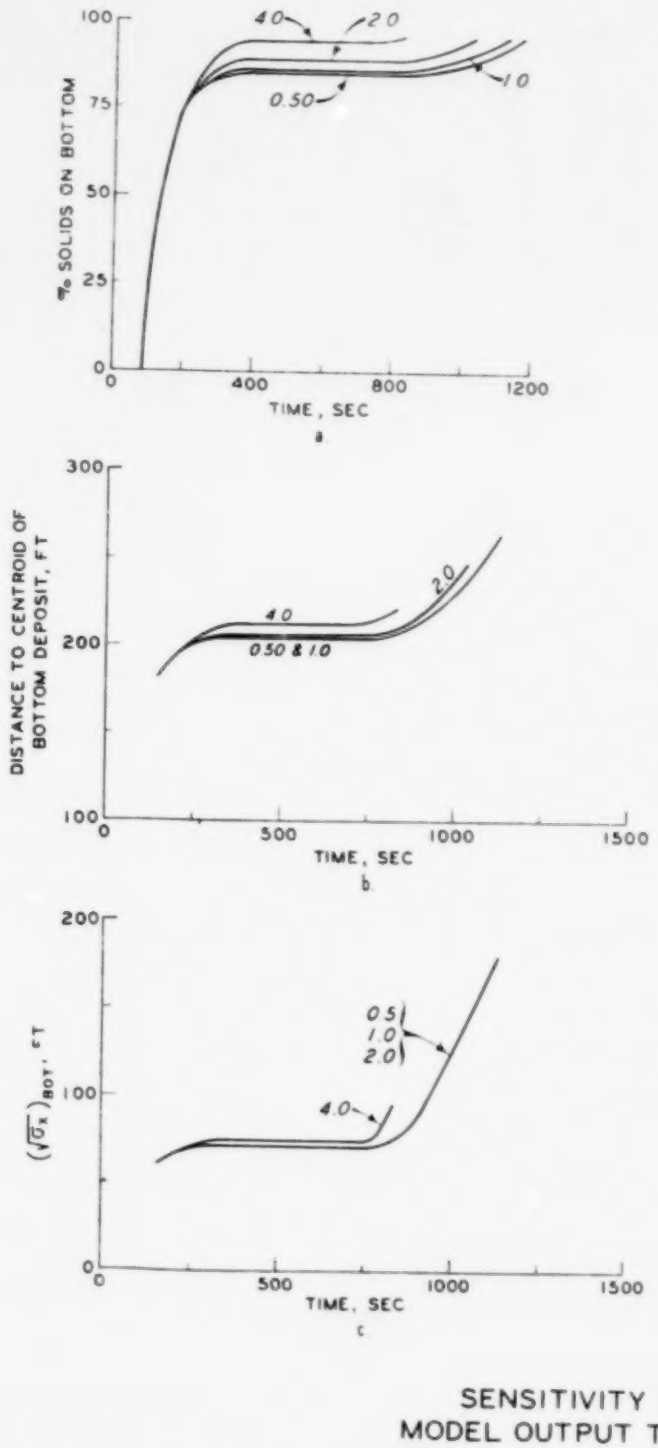

SENSITIVITY OF
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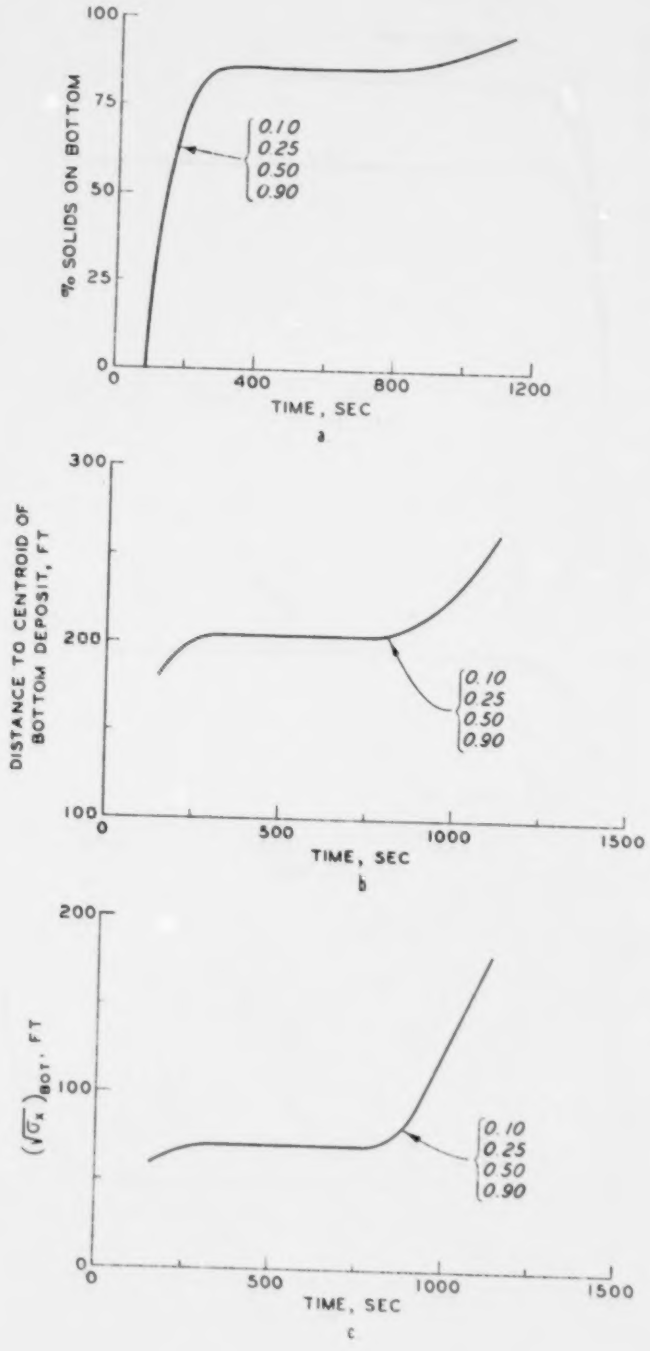

SENSITIVITY OF
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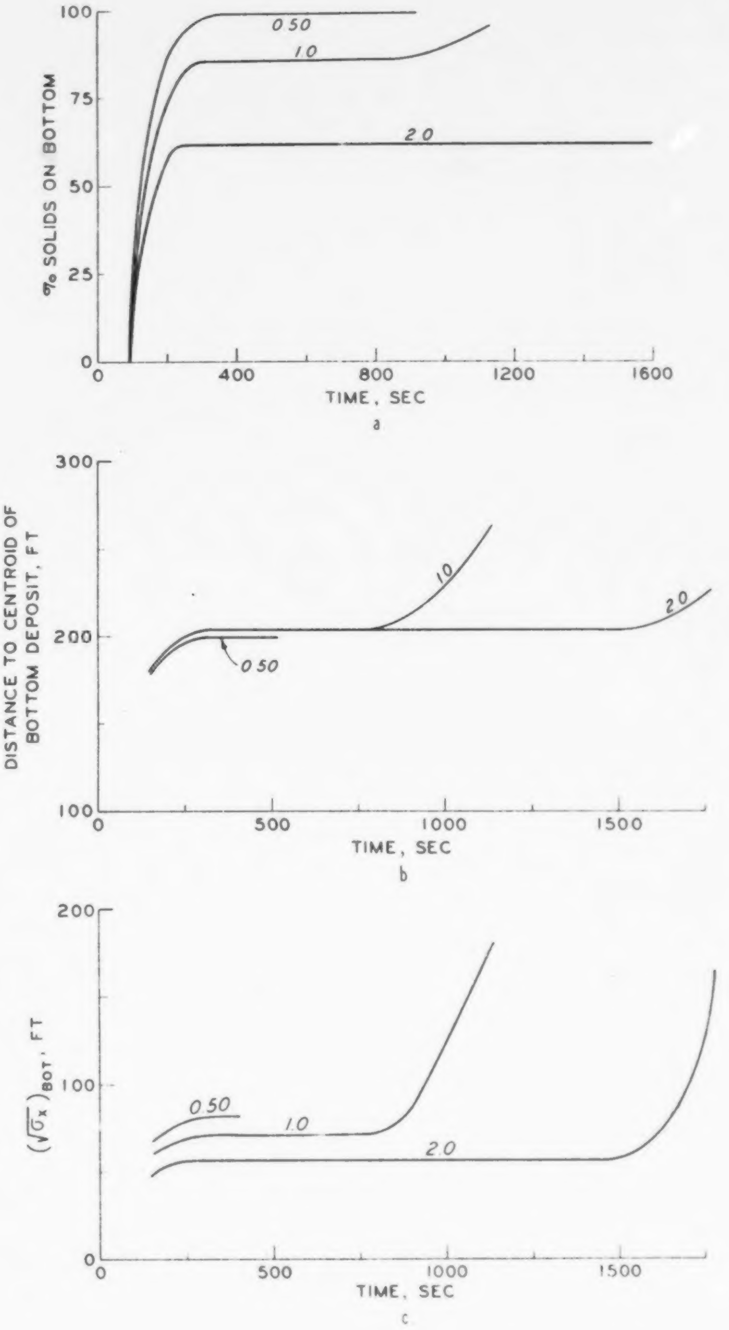
IN BOTTOM DUMP DISPOSAL



SENSITIVITY OF
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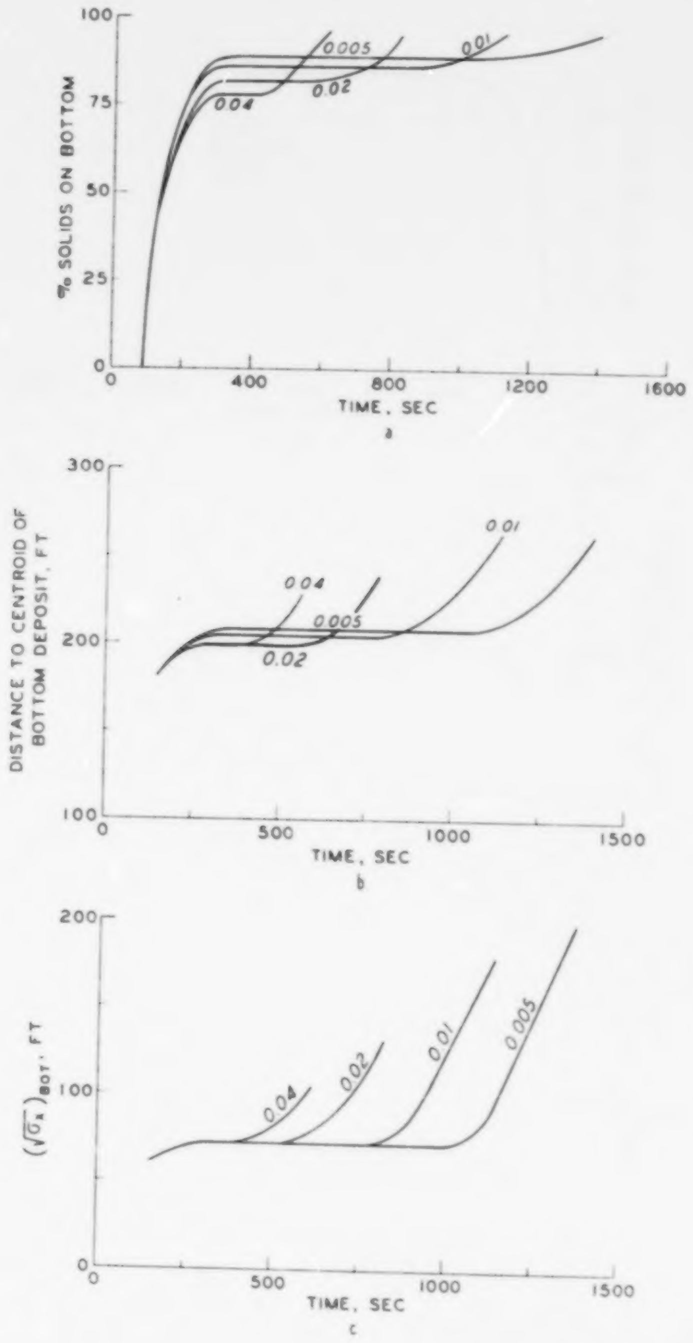

SENSITIVITY OF
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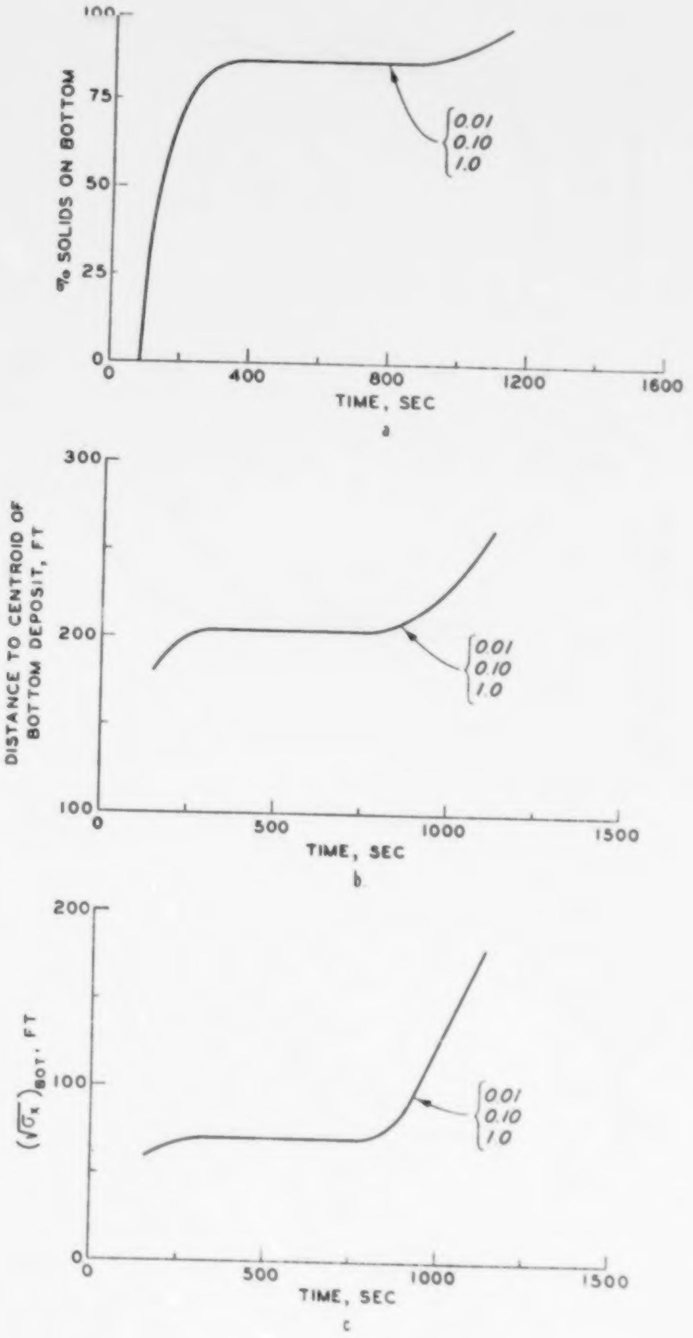
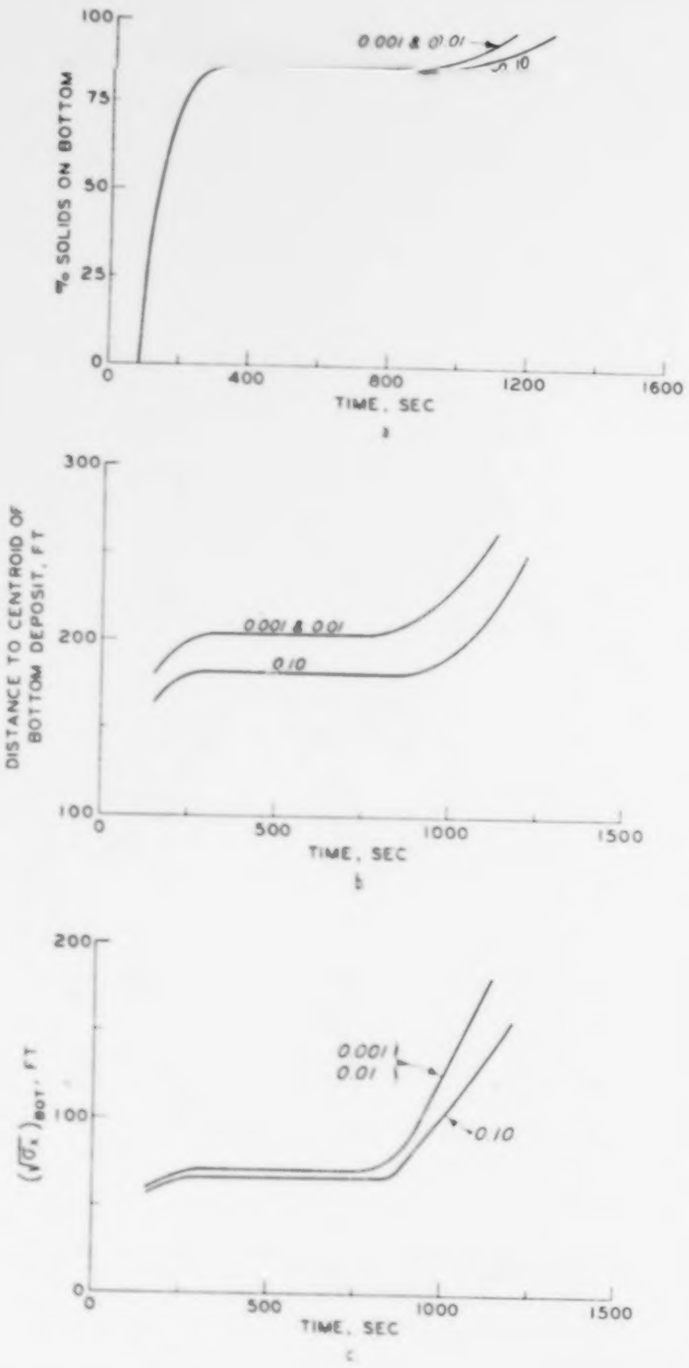
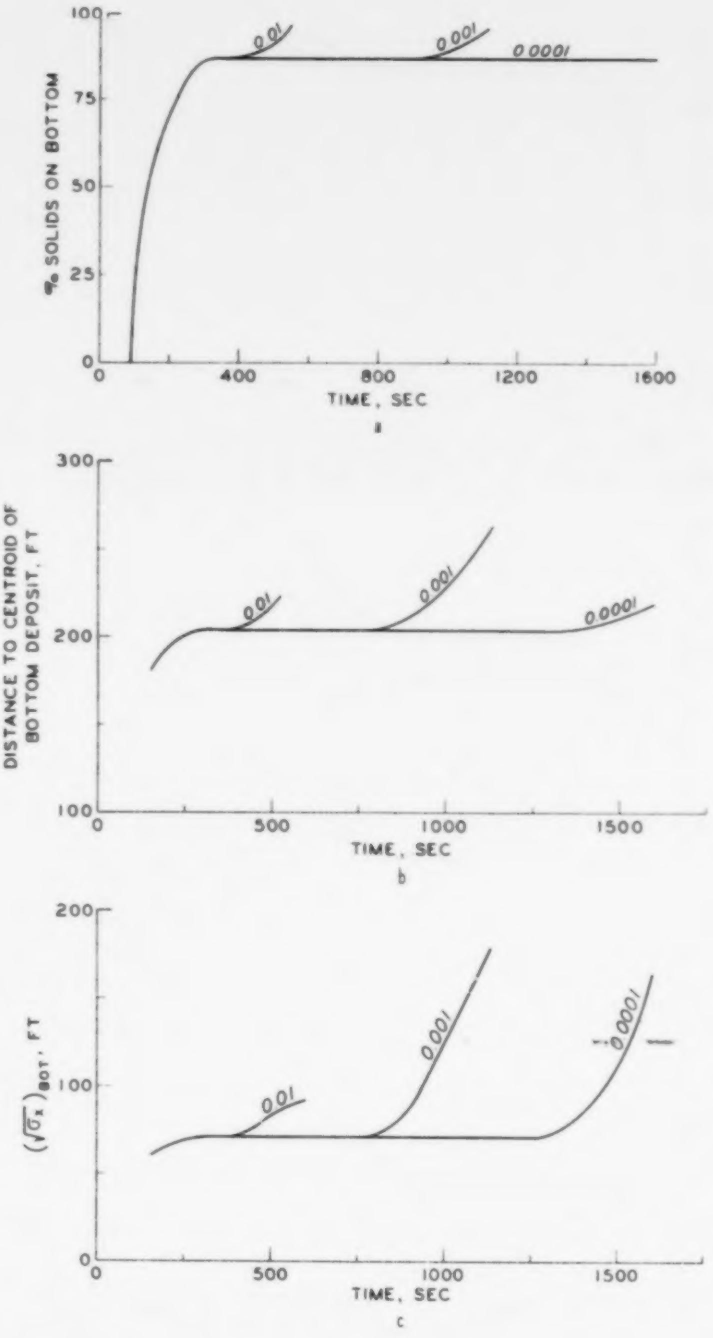


SENSITIVITY OF
MODEL OUTPUT TO F_1
IN BOTTOM DUMP DISPOSAL

PLATE 11



SENSITIVITY OF
MODEL OUTPUT TO FRICTN
IN BOTTOM DUMP DISPOSAL



SENSITIVITY OF
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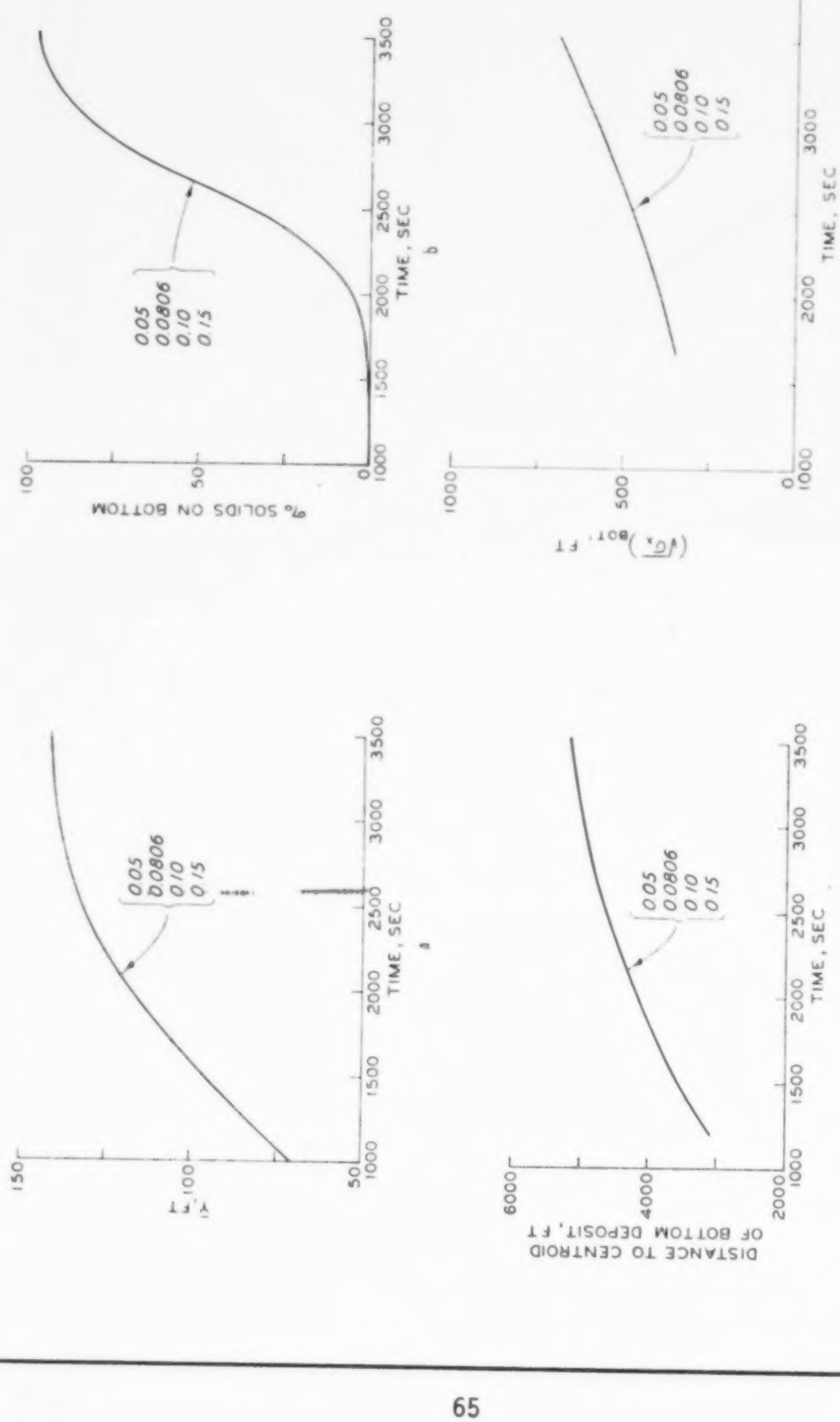
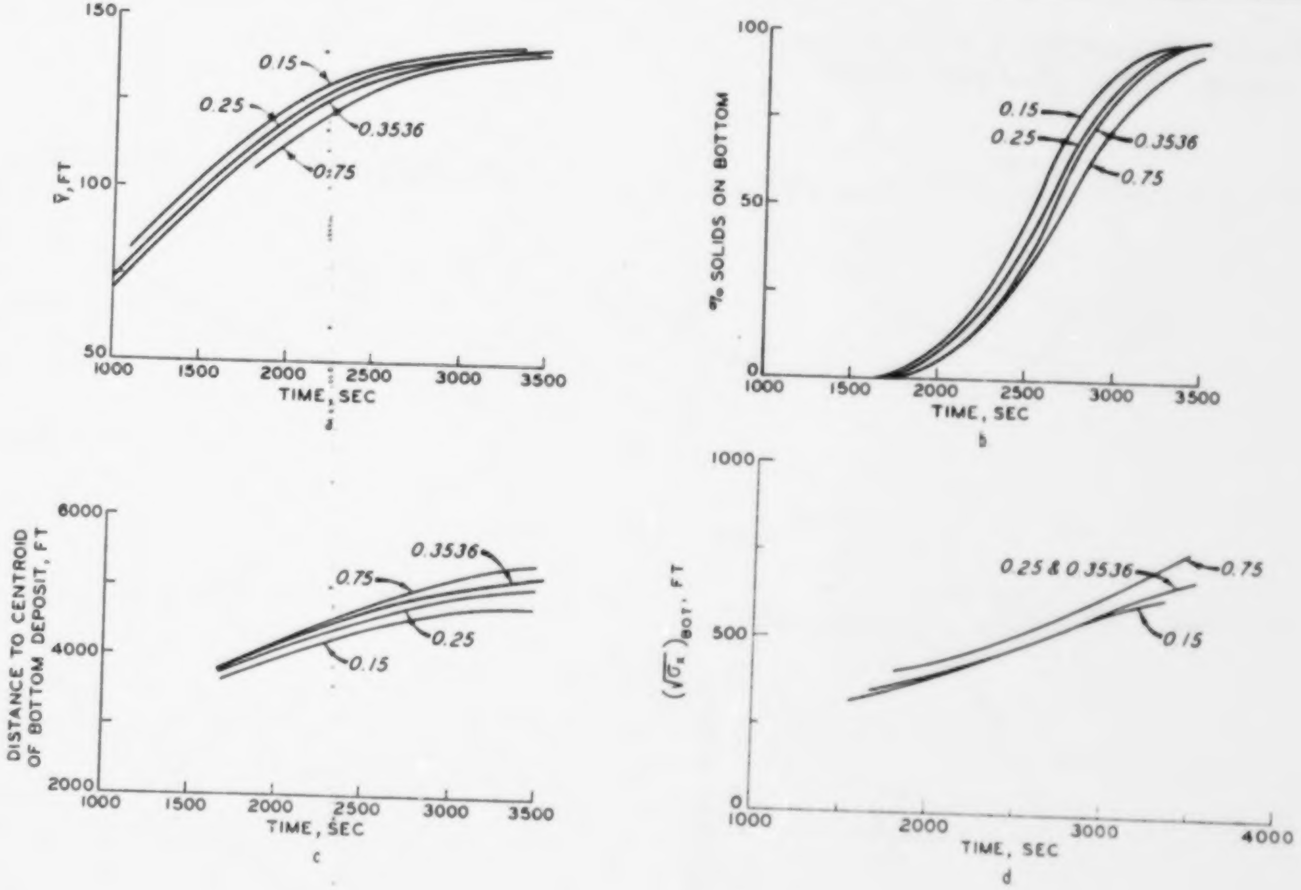
IN BOTTOM DUMP DISPOSAL



SENSITIVITY OF MODEL OUTPUT TO α_1 IN JET DISCHARGE DISPOSAL



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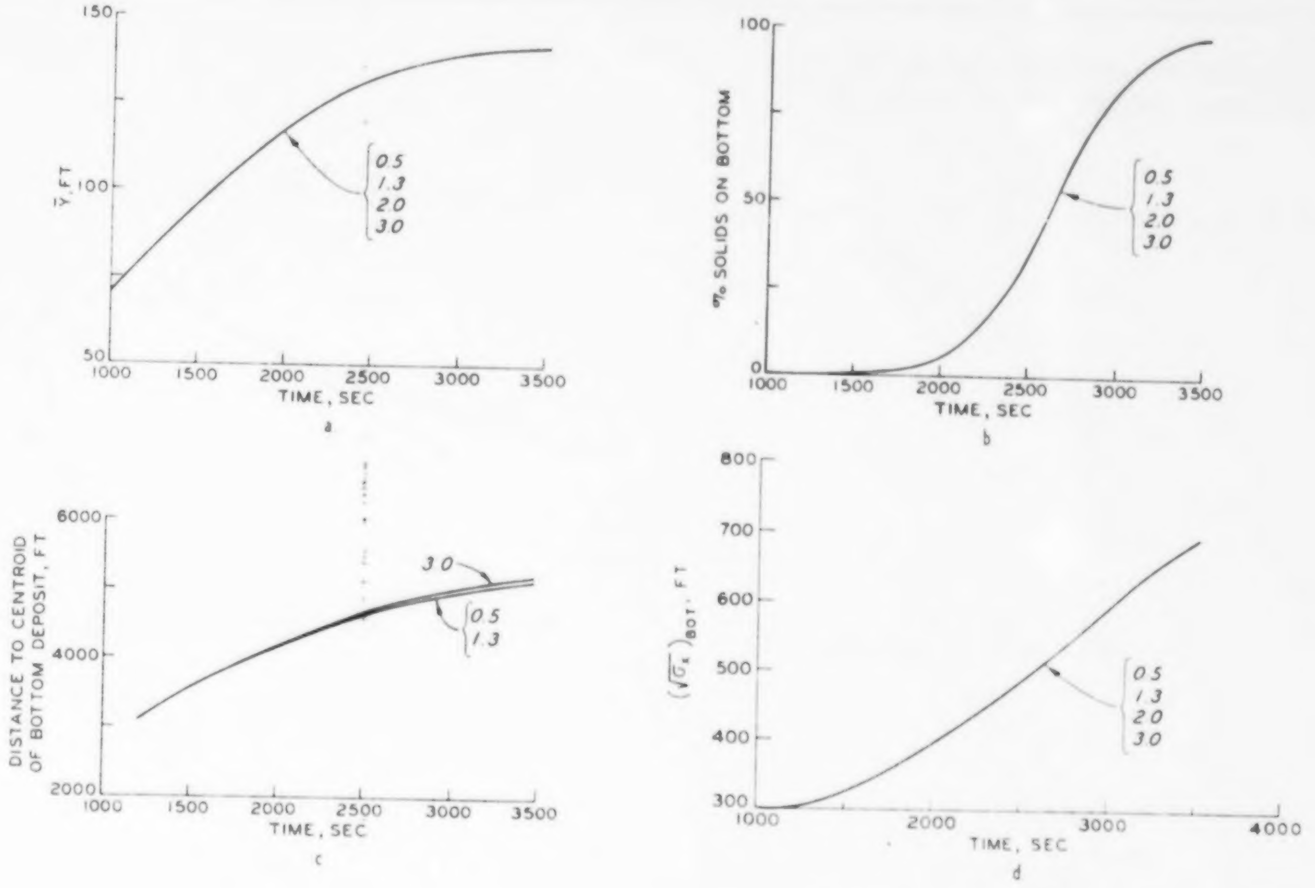

SENSITIVITY OF MODEL OUTPUT
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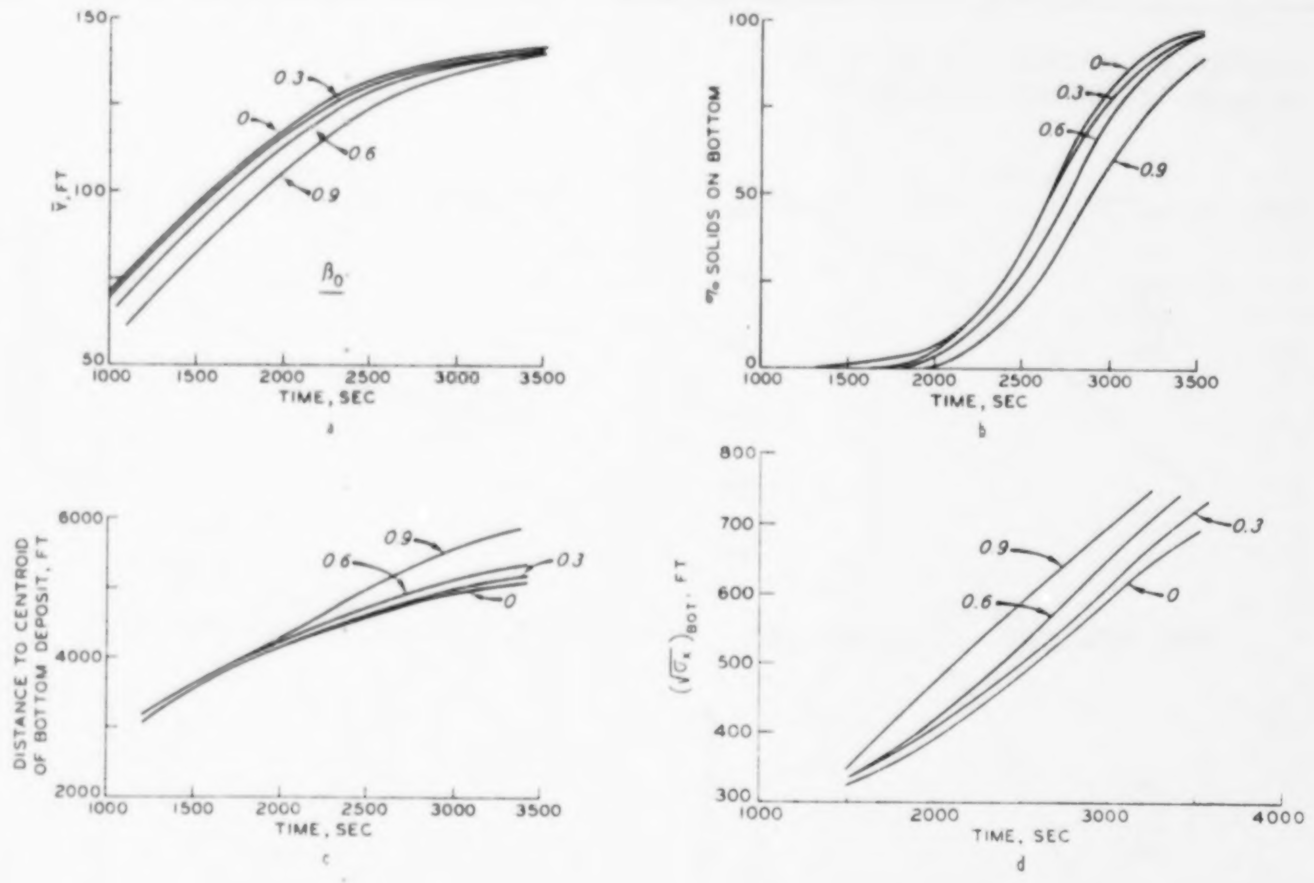

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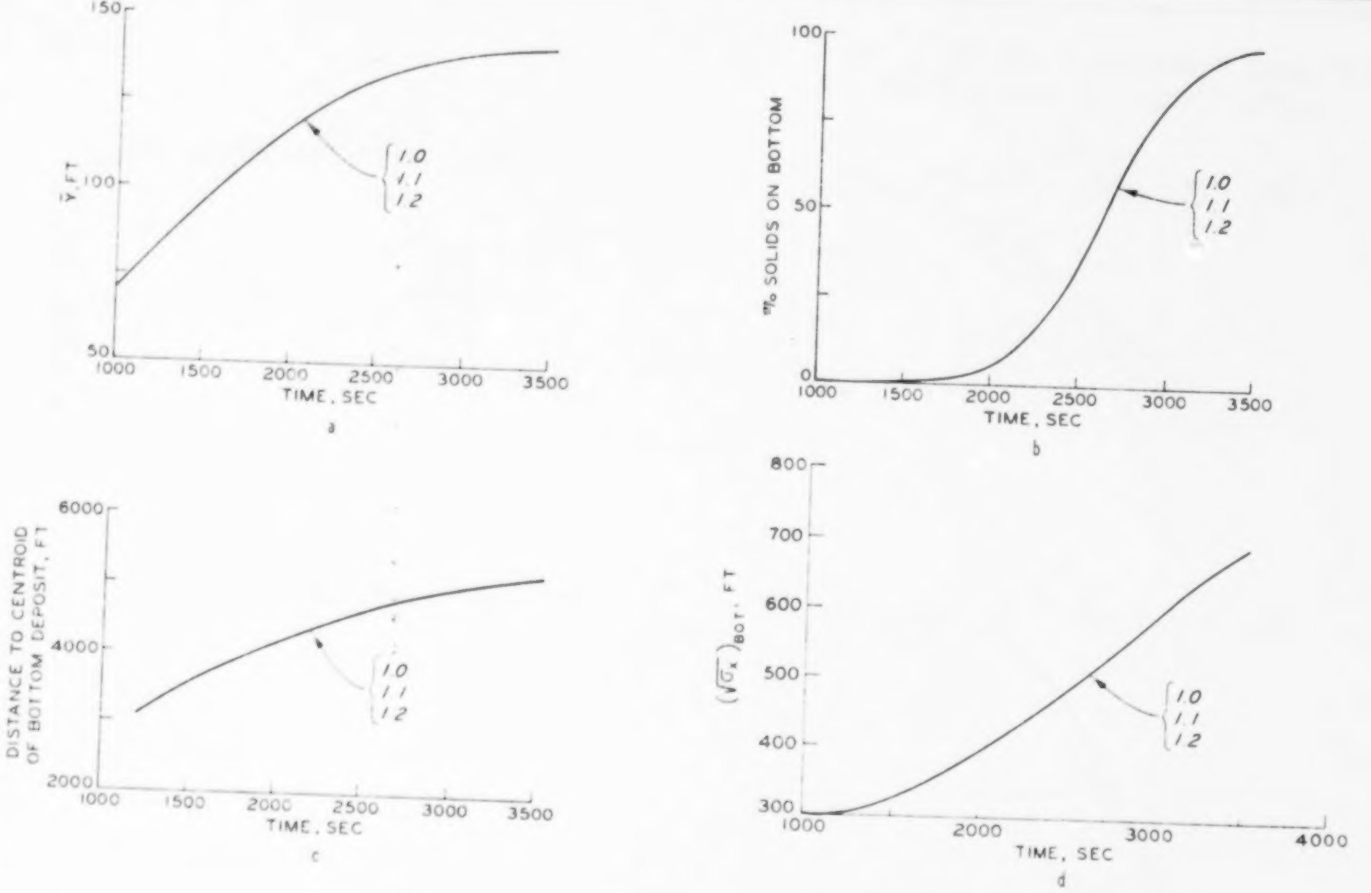
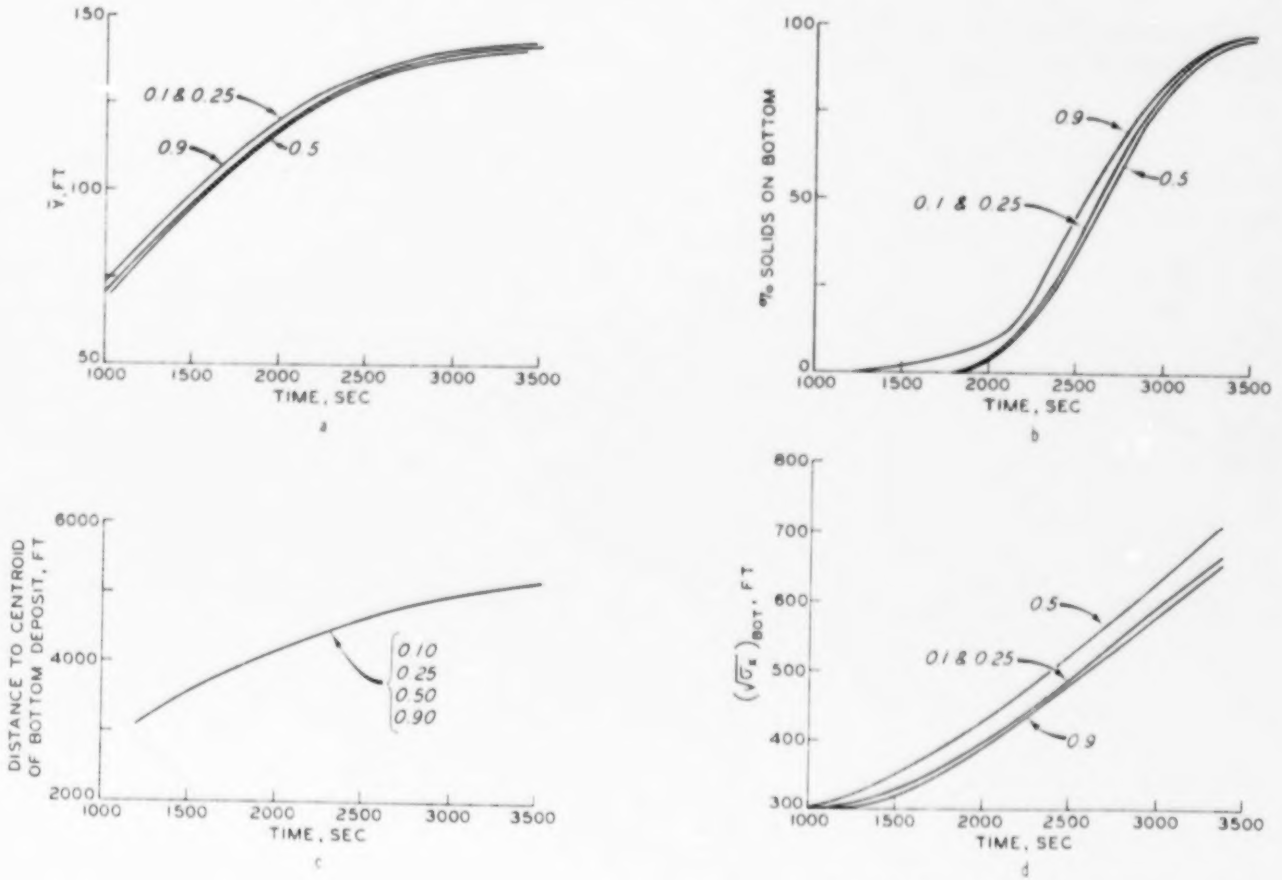


SENSITIVITY OF MODEL OUTPUT
TO C_M IN JET DISCHARGE DISPOSAL



SENSITIVITY OF MODEL OUTPUT
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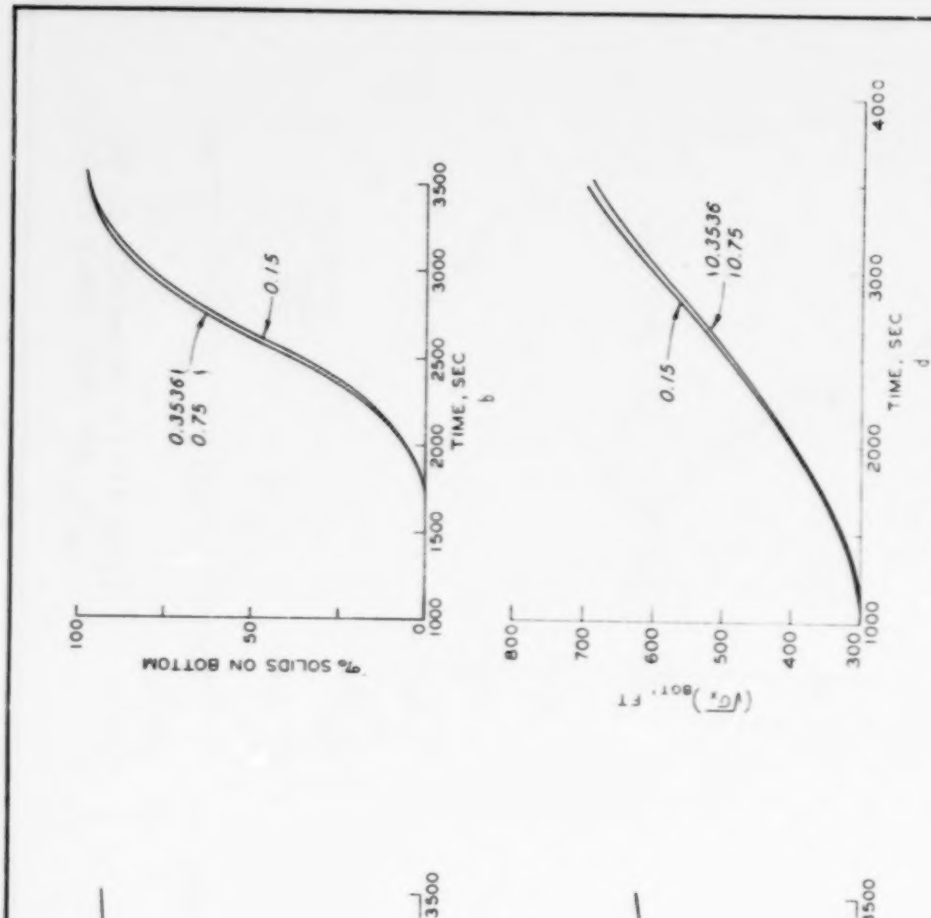

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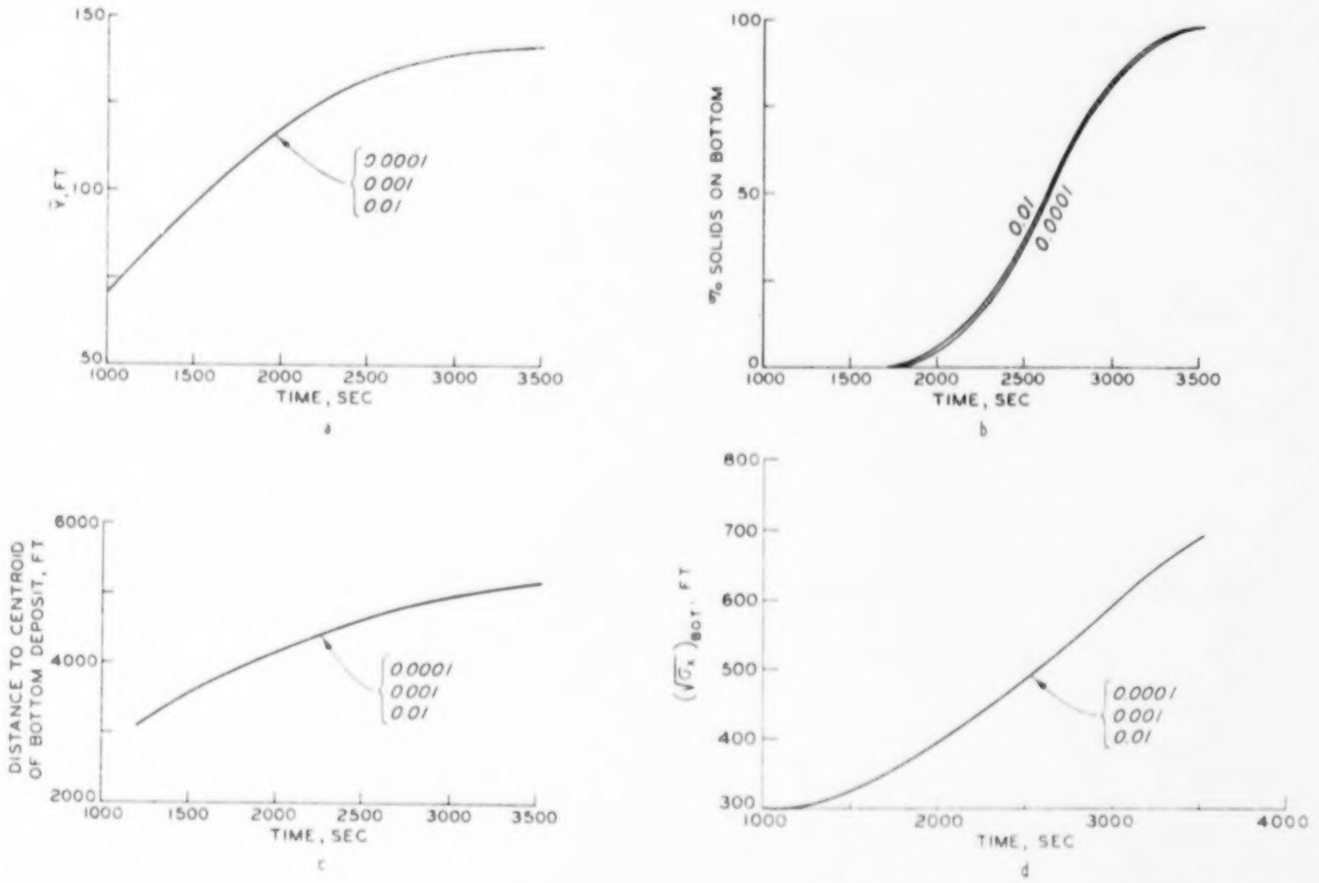

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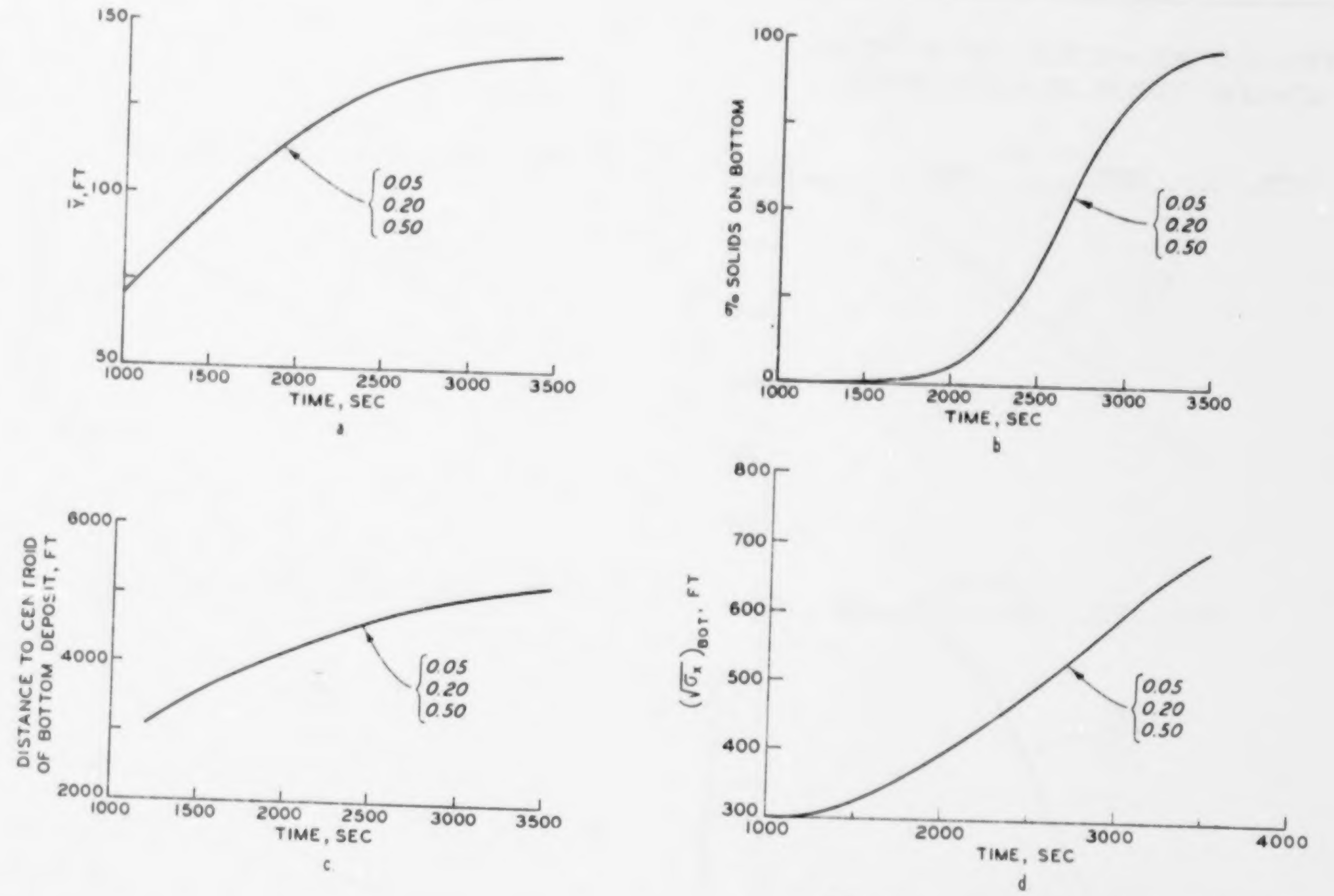
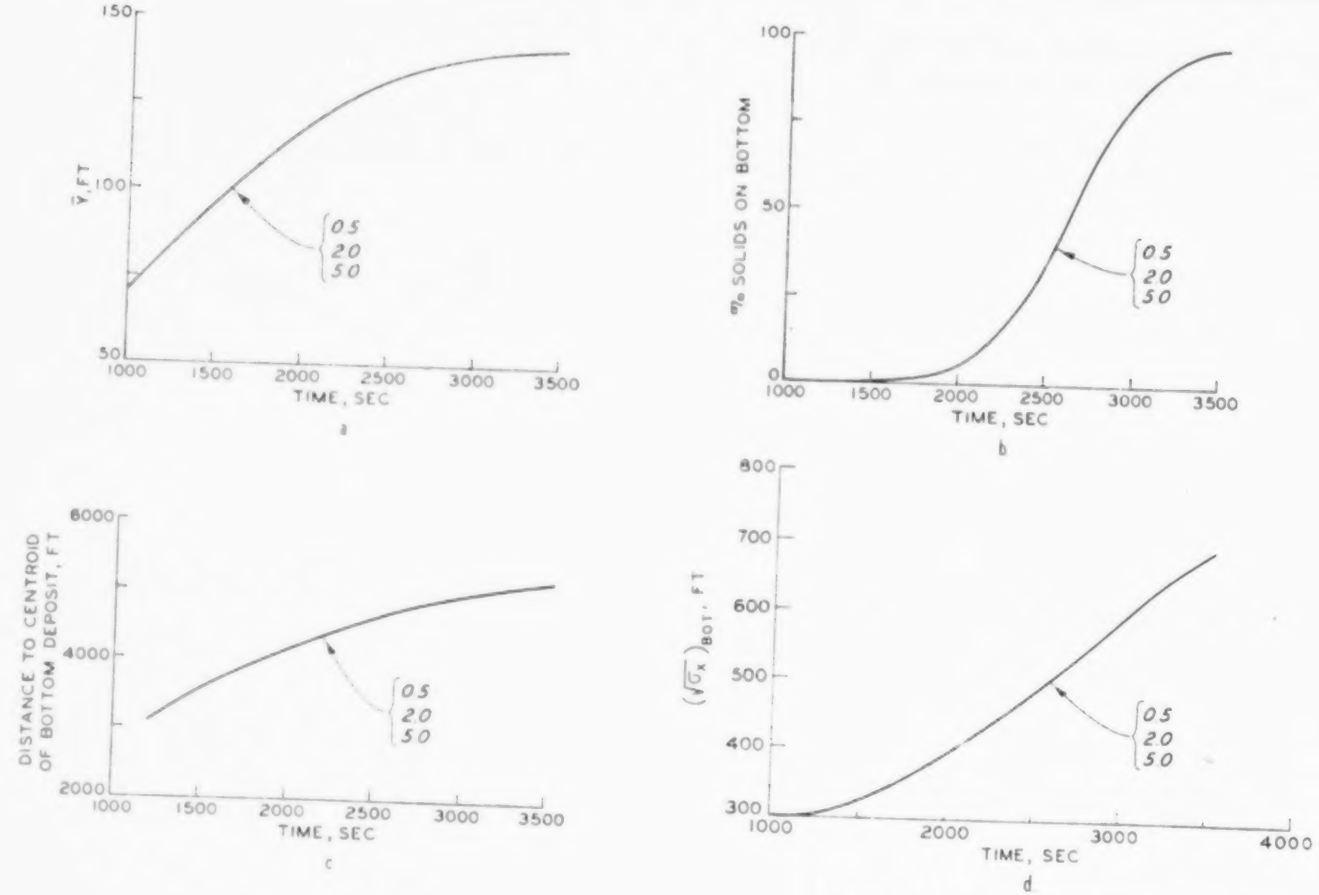


SENSITIVITY OF MODEL OUTPUT TO C_{D_3} IN JET DISCHARGE DISPOSAL



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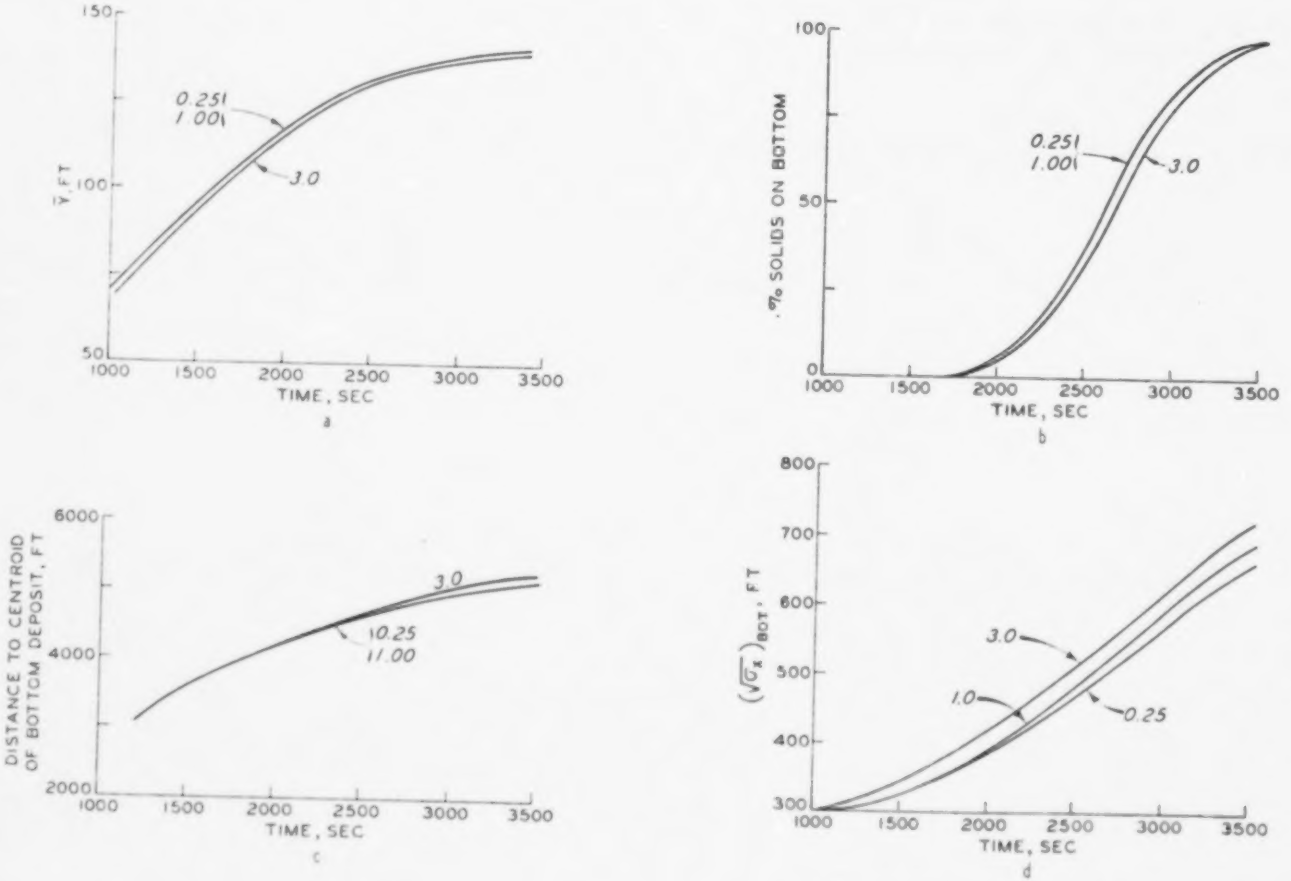

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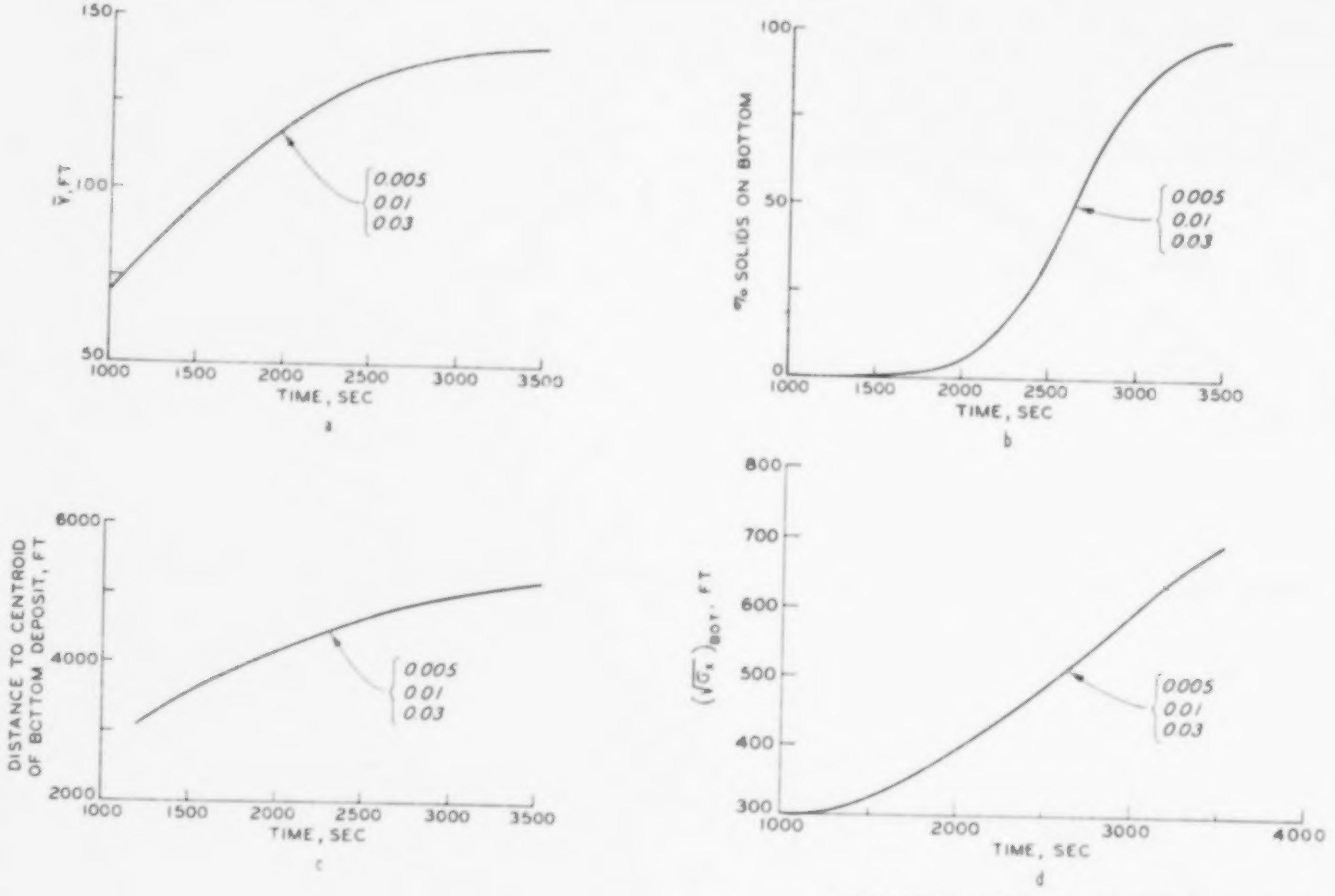

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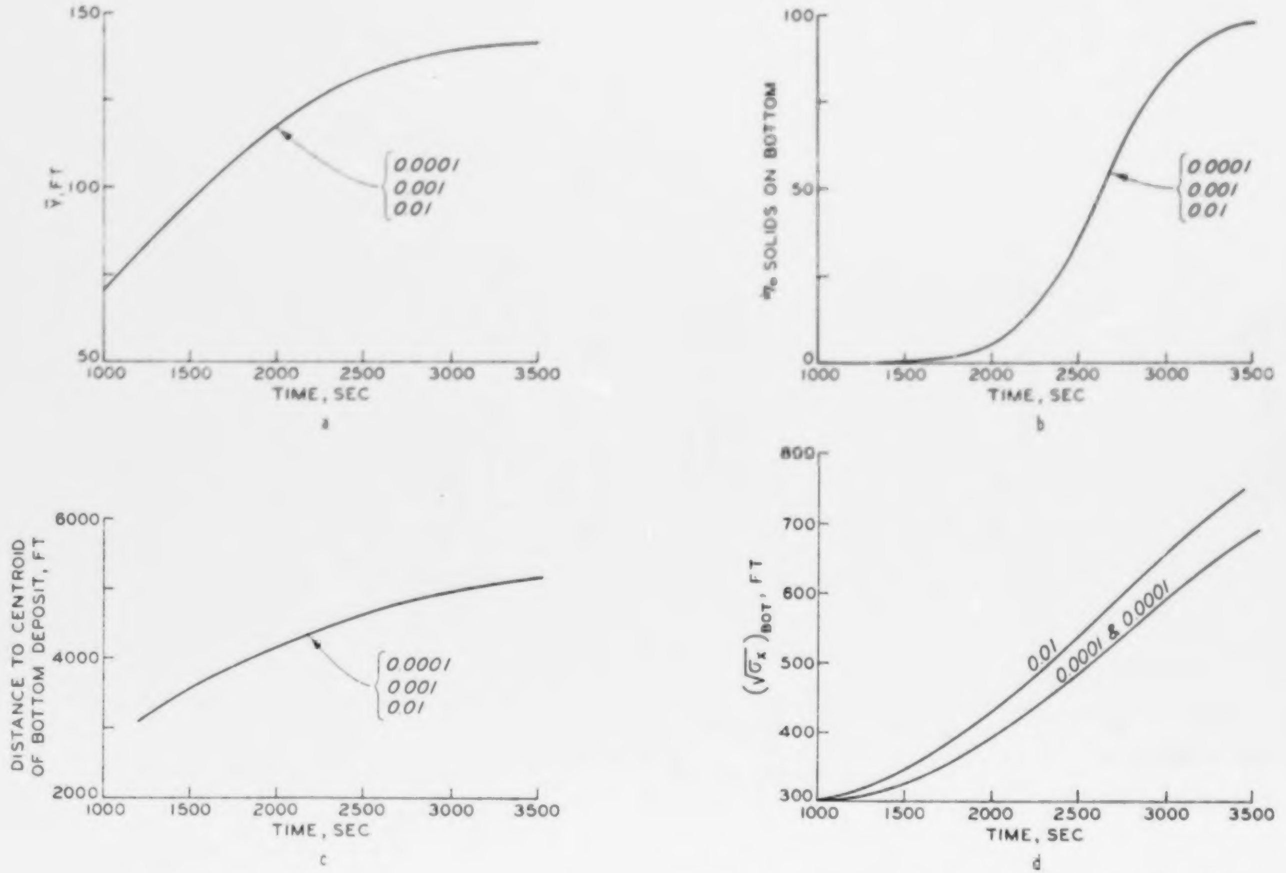
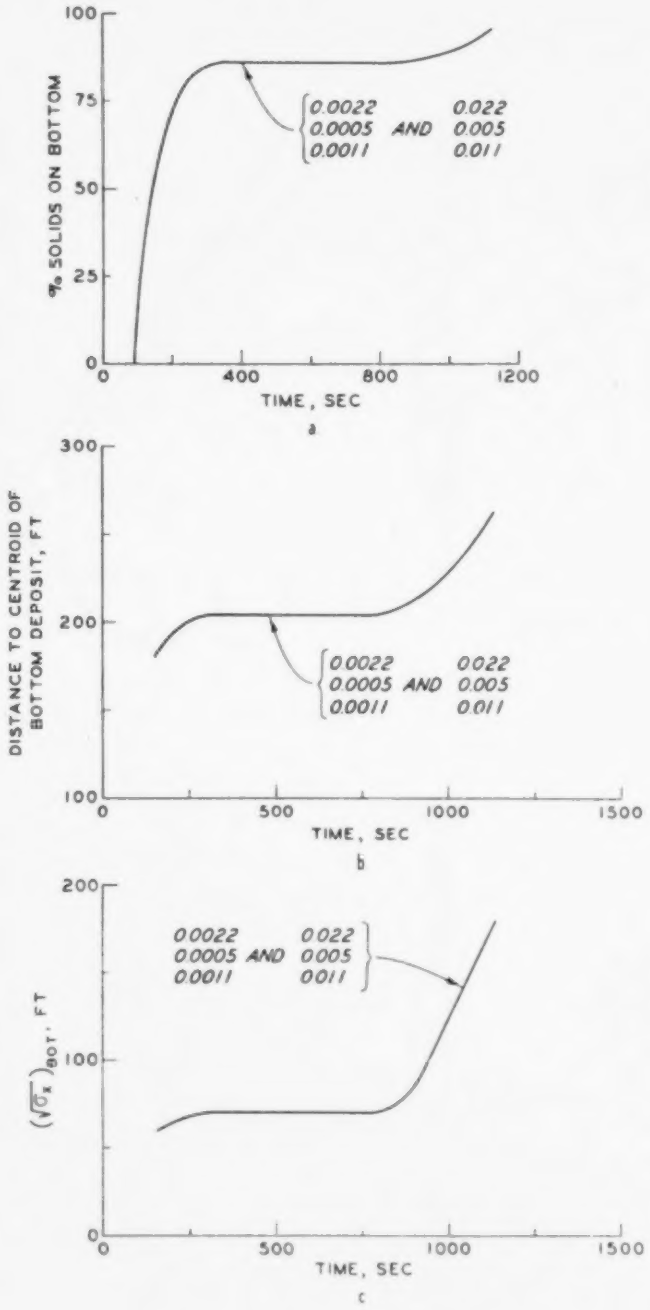
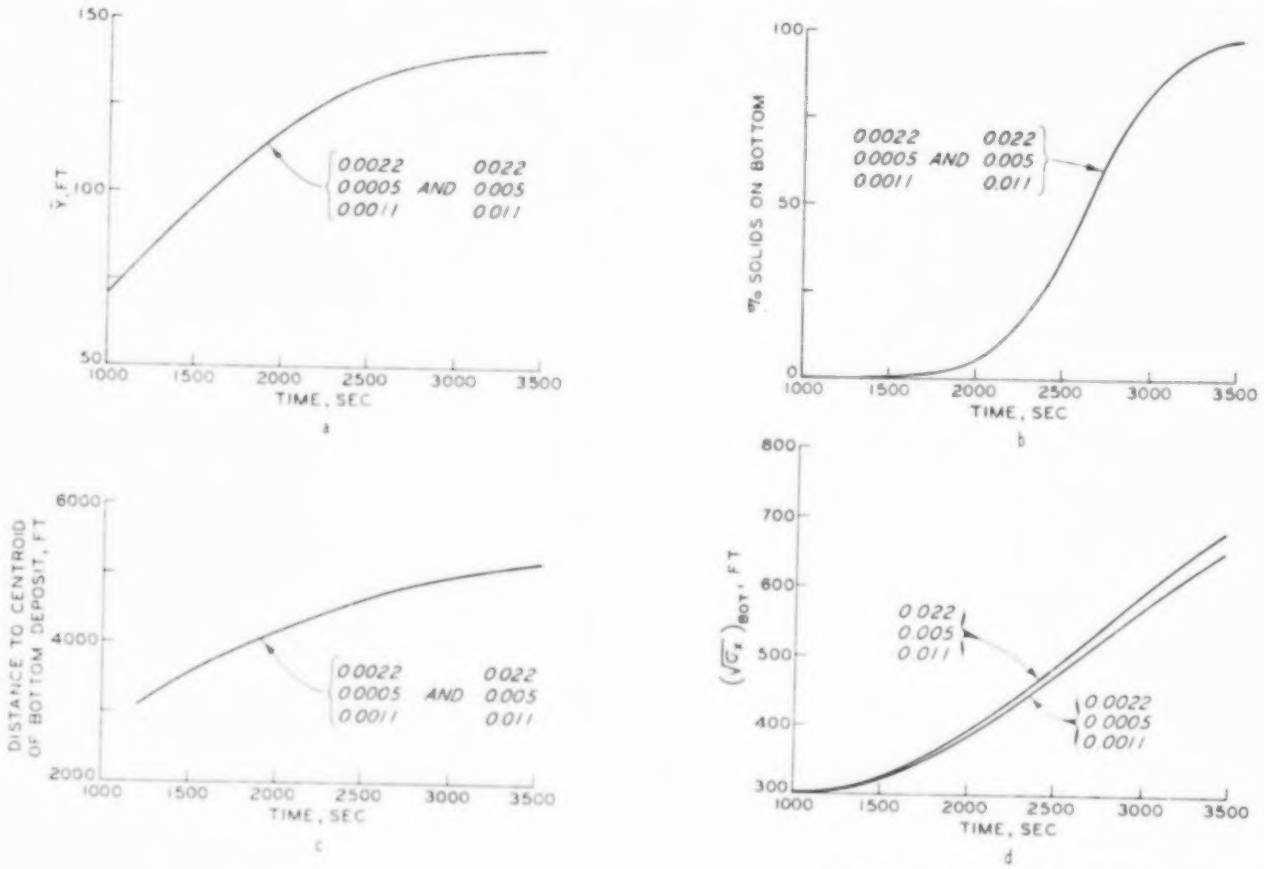


SENSITIVITY OF MODEL OUTPUT
TO λ IN JET DISCHARGE DISPOSAL



SENSITIVITY OF
MODEL OUTPUT TO
VERTICAL DIFFUSION COEFFICIENT
IN BOTTOM DUMP DISPOSAL



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TO VERTICAL DIFFUSION COEFFICIENT
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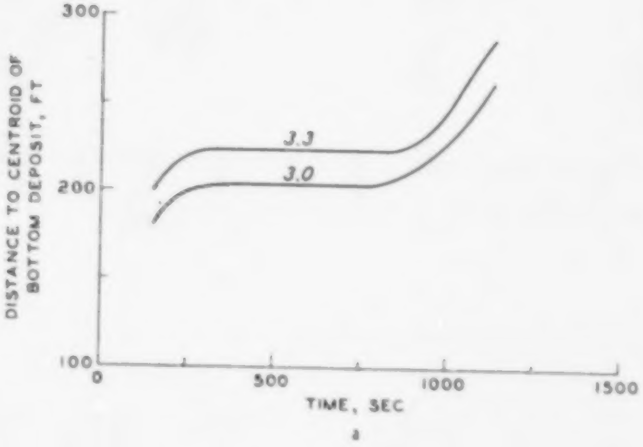

SENSITIVITY OF
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A MINOR VARIATION OF
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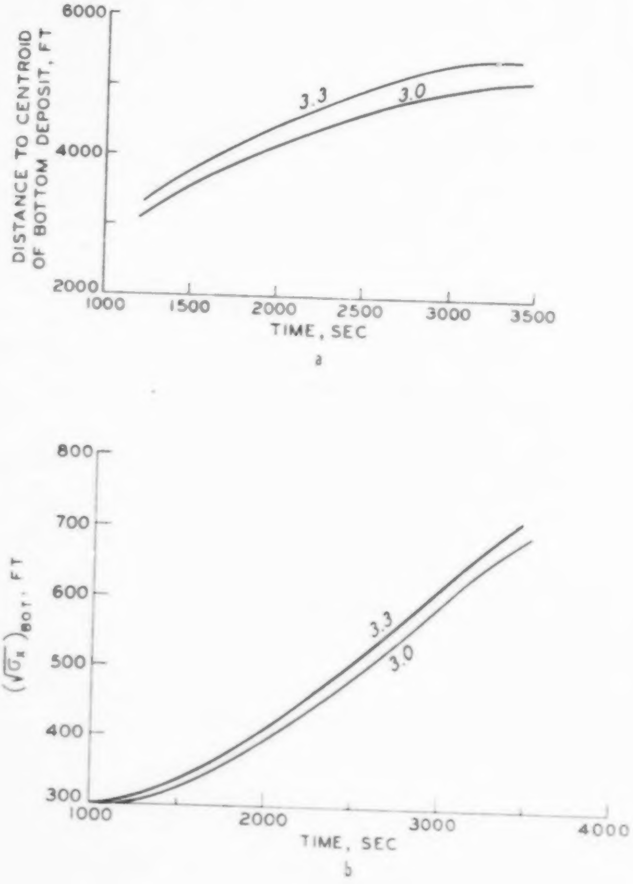
BOTTOM DUMP DISPOSAL



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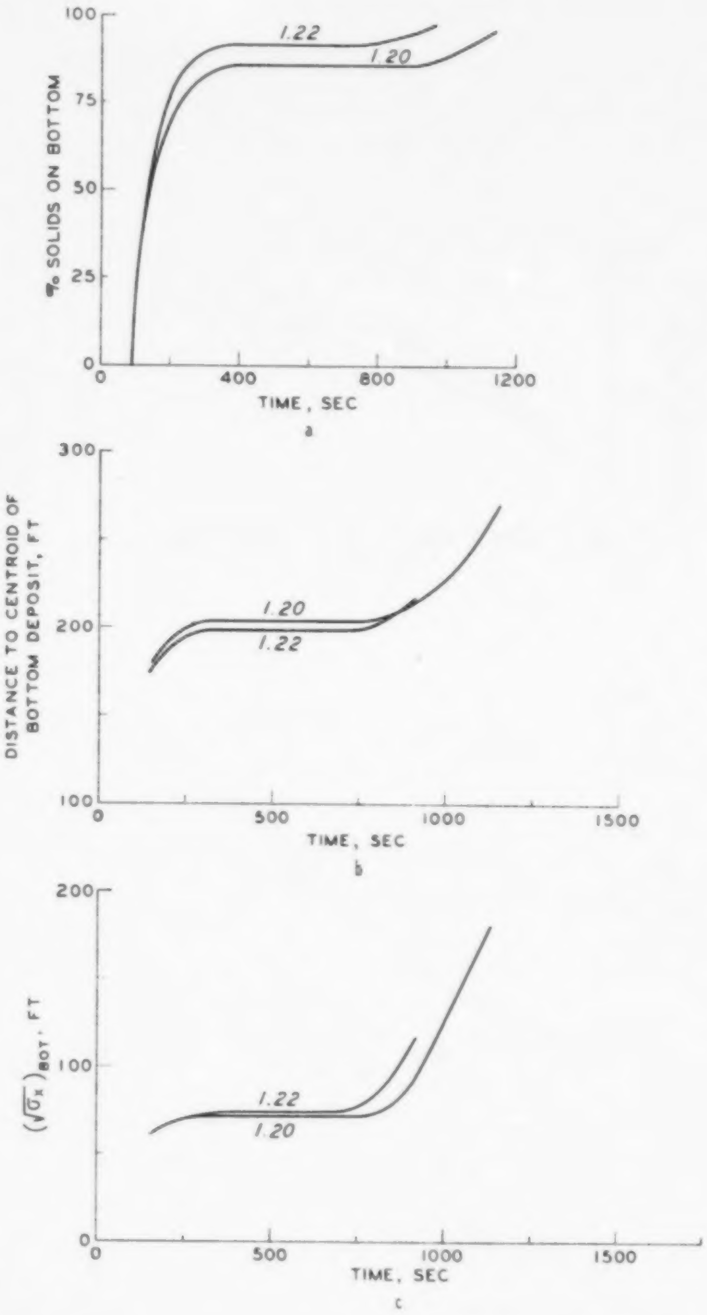

SENSITIVITY OF
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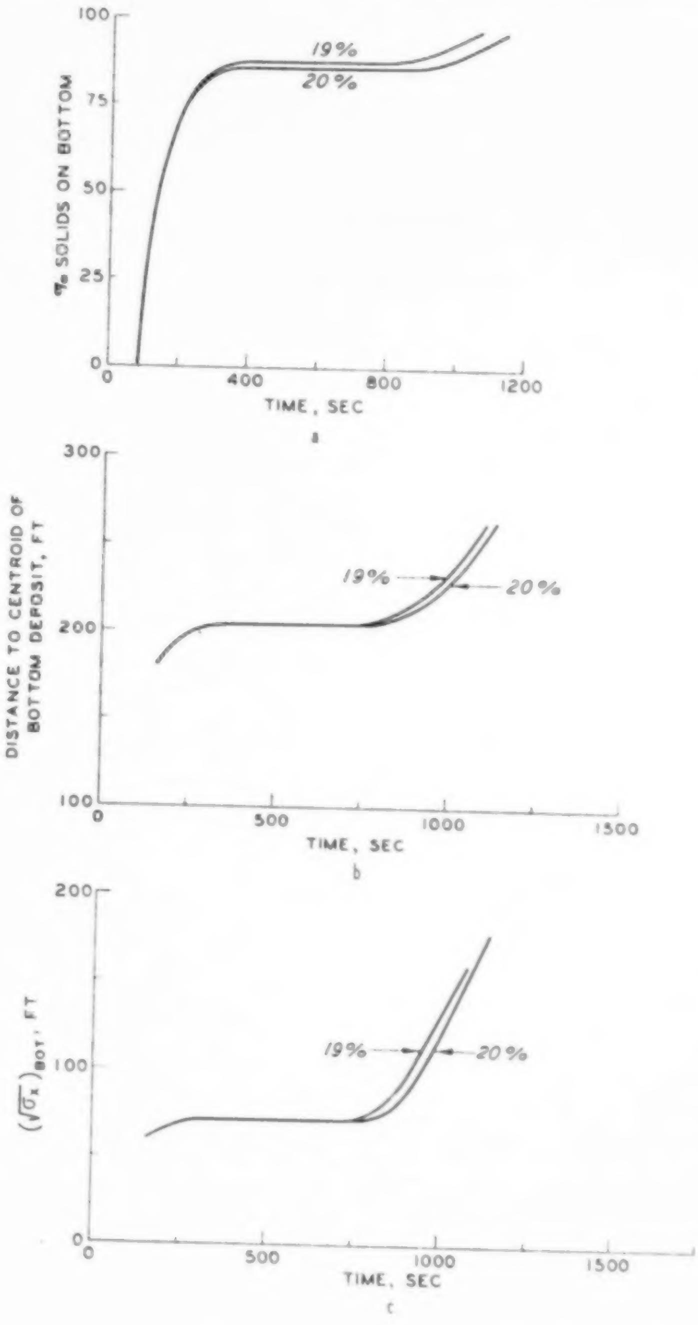
A MINOR VARIATION OF
BULK DENSITY OF DUMPED MATERIAL
IN BOTTOM DUMP DISPOSAL



SENSITIVITY OF
MODEL OUTPUT TO
A MINOR VARIATION OF
SOLIDS CONCENTRATION IN
BOTTOM DUMP DISPOSAL

APPENDIX B

EXAMPLE OUTPUT

Section 1. Columbia River Hopper Dredge Discharge

```
 AMBIENT CONDITIONS
DEPTH IN FT.  DENSITY IN GRAM PER CC.  KY IN SQFT PER SEC.  VEL. IN FPS.
DEPTH              0.          1.0000E+02
AMB-DENSITY      1.0200E+00  1.0250E+00

YK                    3.0000E+01  3.5000E+01  4.0000E+01  4.5000E+01
KY                    2.2000E-03  5.0000E-04  1.1000E-03

YU 2.0000E+01YW 2.0000E+01YE 1.0000E+02H 1.0000E+02
UA 2.5000E+00WA 0.


BARGE OPERATION 2
DISCHARGE THROUGH A NOZZLE UNDER A MOVING BARGE

TSTOP  3.0000E+03SEC.

GRID POINT SIZE   51 KEY1    1 KEY2    3 KEY3    1

USE TETRA TECH SUGGESTED COEFFICIENTS

DINCR1     1.0000 DINCR2    1.0000
ALPHA1      .0806  ALPHA2      .3536  BETA    0.0000 CD     1.3000
GAMA  .25 CDRAG 1.00 CFRIC .010 CD3  .20 CD4 2.00 ALPHA3      .3536
ALPHA4      .0010 FRICTN      .0100 F1      .1000 CM     1.0000
ALFA1    1.0000 ALFA2     1.0000 GAMA1     0.0000 GAMA2     0.0000
ALAMDA      .0010

JET RADIUS       2.5800  DENSITY      1.4800  ANGLE OF JET     0.0000
VELOCITY       .1340 AT   13.0000 FT.
       R    1  L    1
DENSITY OF SOLID             2.5000E+00
CONCENTRATION                3.0000E-01
FALL VELOCITY OF SOLID       5.0000E-02
BARGE VELOCITY     9.8400 ANGLE WITH X-AXIS  180.0000 DEGREES FOR7.5650E+02 SEC.

AMBIENT CURRENT FOR A MOVING COORDINATE FIXED ON THE BARGE
    U       YU       YW       YE       H
 12.3400 12.3400           9.8400   9.8400
 -0.0000           0.0000 -0.0000  -0.0000
```

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```
        JET CONVECTION

    1  1.0000E+00  2.5800E+00     0    1   45

    2  3.2143E-01  2.5800E+00     0    1   91

    3  2.3443E-01  2.5800E+00     0    1  127

           T          S          X          Y          Z        U   RADIUS     DEN-DIF   FLUID CONC.FLUX OF SOLID  CONCENTRATION
        0.00       0.00       0.00      13.00       0.00     .134    2.580  4.5934E-01  7.0000E-01  8.4065E-01  3.0000E-01
        4.47       1.25        .81      13.44       0.00   12.914     .381  2.1651E-01  3.3302E-01  8.4065E-01  1.4272E-01
        4.59       2.75       2.14      13.70       0.00   12.674     .498  1.3051E-01  1.9892E-01  8.4065E-01  8.5252E-02
        4.74       4.57       3.77      14.03       0.00   12.596     .595  9.1983E-02  1.4022E-01  8.4065E-01  6.0093E-02
        4.91       6.78       5.76      14.28       0.00   12.553     .688  6.8886E-02  1.0502E-01  8.4065E-01  4.5011E-02
        5.12       9.45       8.18      14.55       0.00   12.524     .785  5.3000E-02  8.0823E-02  8.4065E-01  3.4639E-02
        5.38      12.68      11.10      14.86       0.00   12.501     .890  4.1294E-02  6.2992E-02  8.4065E-01  2.6996E-02
        5.69      16.59      14.64      15.16       0.00   12.482    1.007  3.2352E-02  4.9372E-02  8.4065E-01  2.1159E-02
        6.07      21.32      18.92      15.51       0.00   12.466    1.137  2.5392E-02  3.8775E-02  8.4065E-01  1.6618E-02
        6.53      27.04      24.11      15.92       0.00   12.452    1.283  1.9928E-02  3.0459E-02  8.4065E-01  1.3054E-02
        7.09      33.96      30.38      16.37       0.00   12.439    1.449  1.5622E-02  2.3909E-02  8.4065E-01  1.0247E-02
        7.76      42.34      37.98      16.89       0.00   12.428    1.637  1.2227E-02  1.8747E-02  8.4065E-01  8.0344E-03
        8.58      52.47      47.18      17.48       0.00   12.417    1.851  9.5498E-03  1.4683E-02  8.4065E-01  6.2926E-03
        9.57      64.74      58.31      18.15       0.00   12.409    2.093  7.4420E-03  1.1488E-02  8.4065E-01  4.9233E-03
       10.76      79.58      71.78      18.91       0.00   12.401    2.368  5.7837E-03  8.9802E-03  8.4065E-01  3.8486E-03
       12.21      97.53      88.03      19.77       0.00   12.393    2.680  4.4801E-03  7.0156E-03  8.4065E-01  3.0067E-03
       13.91     118.66     107.80      20.75       0.00   12.385    3.034  3.4536E-03  5.4762E-03  8.4065E-01  2.3469E-03
       15.66     140.22     129.34      21.75       0.00   12.372    3.400  2.7075E-03  4.3643E-03  8.4065E-01  1.8704E-03
       17.40     161.78     150.88      22.70       0.00   12.358    3.749  2.1667E-03  3.5943E-03  8.4065E-01  1.5404E-03
       19.14     183.35     172.43      23.60       0.00   12.342    4.083  1.8046E-03  3.0343E-03  8.4065E-01  1.3004E-03
       20.89     204.91     193.97      24.45       0.00   12.326    4.404  1.5133E-03  2.6114E-03  8.4065E-01  1.1192E-03
       22.64     226.47     215.52      25.27       0.00   12.310    4.714  1.2843E-03  2.2826E-03  8.4065E-01  9.7827E-04
       24.39     248.03     237.06      26.06       0.00   12.295    5.013  1.0999E-03  2.0208E-03  8.4065E-01  8.6605E-04
       26.15     269.59     258.61      26.82       0.00   12.280    5.303  9.4830E-04  1.8082E-03  8.4065E-01  7.7494E-04
       27.90     291.15     280.16      27.55       0.00   12.264    5.584  8.2159E-04  1.6327E-03  8.4065E-01  6.9974E-04
       29.66     312.71     301.71      28.25       0.00   12.250    5.857  7.1413E-04  1.4859E-03  8.4065E-01  6.3682E-04
       31.42     334.28     323.25      28.93       0.00   12.236    6.122  6.2188E-04  1.3616E-03  8.4065E-01  5.8353E-04
       33.19     355.84     344.81      29.59       0.00   12.222    6.380  5.4184E-04  1.2552E-03  8.4065E-01  5.3795E-04
       34.95     377.40     366.36      30.22       0.00   12.208    6.630  4.7176E-04  1.1634E-03  8.4065E-01  4.9860E-04
       36.72     398.96     387.92      30.83       0.00   12.195    6.874  4.0991E-04  1.0835E-03  8.4065E-01  4.6436E-04
       38.49     420.52     409.47      31.42       0.00   12.182    7.111  3.5493E-04  1.0135E-03  8.4065E-01  4.3436E-04
       40.26     442.08     431.02      31.99       0.00   12.170    7.342  3.0577E-04  9.5180E-04  8.4065E-01  4.0792E-04
       42.03     463.64     452.58      32.54       0.00   12.158    7.566  2.6158E-04  8.9710E-04  8.4065E-01  3.8447E-04
       43.80     485.21     474.13      33.06       0.00   12.146    7.784  2.2167E-04  8.4835E-04  8.4065E-01  3.6356E-04
       45.58     506.77     495.69      33.57       0.00   12.135    7.996  1.8548E-04  8.0475E-04  8.4065E-01  3.4489E-04
       47.36     528.33     517.25      34.06       0.00   12.124    8.202  1.5256E-04  7.6557E-04  8.4065E-01  3.2810E-04
       49.13     549.89     538.80      34.53       0.00   12.113    8.402  1.2252E-04  7.3025E-04  8.4065E-01  3.1296E-04
       50.92     571.45     560.36      34.99       0.00   12.103    8.595  9.5040E-05  6.9829E-04  8.4065E-01  2.9927E-04
       52.70     593.01     581.92      35.42       0.00   12.093    8.783  6.9860E-05  6.6930E-04  8.4065E-01  2.8684E-04
       54.49     614.57     603.47      35.83       0.00   12.083    8.965  4.6749E-05  6.4294E-04  8.4065E-01  2.7555E-04
       56.27     636.14     625.03      36.23       0.00   12.074    9.141  2.5514E-05  6.1891E-04  8.4065E-01  2.6525E-04
       58.05     657.70     646.59      36.61       0.00   12.065    9.311  5.9919E-06  5.9695E-04  8.4065E-01  2.5584E-04
       59.84     679.26     668.15      36.97       0.00   12.057    9.475 -1.1960E-05  5.7687E-04  8.4065E-01  2.4723E-04
       61.63     700.82     689.71      37.32       0.00   12.049    9.633 -2.8465E-05  5.5845E-04  8.4065E-01  2.3934E-04
       63.42     722.38     711.26      37.64       0.00   12.041    9.785 -4.3628E-05  5.4157E-04  8.4065E-01  2.3210E-04
       65.21     743.94     732.82      37.95       0.00   12.034    9.931 -5.7542E-05  5.2606E-04  8.4065E-01  2.2545E-04
       67.00     765.50     754.38      38.24       0.00   12.026   10.072 -7.0286E-05  5.1180E-04  8.4065E-01  2.1934E-04
       68.79     787.07     775.94      38.51       0.00   12.020   10.206 -8.1933E-05  4.9868E-04  8.4065E-01  2.1372E-04
       70.59     808.63     797.50      38.77       0.00   12.013   10.335 -9.2543E-05  4.8662E-04  8.4065E-01  2.0855E-04
       72.38     830.19     819.06      39.00       0.00   12.007   10.457 -1.0217E-04  4.7552E-04  8.4065E-01  2.0379E-04
       74.18     851.75     840.62      39.22       0.00   12.001   10.574 -1.1086E-04  4.6531E-04  8.4065E-01  1.9942E-04
       77.77     894.87     883.74      39.61       0.00   11.991   10.784 -1.2562E-04  4.4731E-04  8.4065E-01  1.9170E-04
       79.57     916.43     905.31      39.78       0.00   11.986   10.888 -1.3175E-04  4.3941E-04  8.4065E-01  1.8832E-04
       81.37     938.00     926.87      39.93       0.00   11.982   10.981 -1.3709E-04  4.3218E-04  8.4065E-01  1.8522E-04
       83.17     959.56     948.43      40.07       0.00   11.978   11.068 -1.4166E-04  4.2557E-04  8.4065E-01  1.8239E-04
       84.97     981.12     969.99      40.18       0.00   11.974   11.144 -1.4550E-04  4.1955E-04  8.4065E-01  1.7981E-04
       86.77    1002.68     991.55      40.28       0.00   11.970   11.223 -1.4861E-04  4.1409E-04  8.4065E-01  1.7747E-04
       88.57    1024.24    1013.11      40.37       0.00   11.967   11.292 -1.5231E-04  4.0916E-04  8.3673E-01  1.7454E-04
       90.37    1045.80    1034.67      40.44       0.00   11.964   11.355 -1.5540E-04  4.0473E-04  8.3251E-01  1.7178E-04
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       97.59    1132.05    1120.92      40.54       0.00   11.956   11.548 -1.6086E-04  3.9163E-04  8.1600E-01  1.6292E-04
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     COLLAPSE PHASE OF THE PLUME
 1  1.0000E+00  1.1548E+01     0     0  599
 2  1.9667E+00  1.1548E+01     0     0  599
 3  3.8678E+00  1.1548E+01     0     3  506
             T         S         X         Y          Z         U         A         B      DEN-DIF   FLUID CONC.   SOLID VOL.   CONCENTRATION
         97.59   1132.05   1120.92     40.54       0.00     11.96     11.55     11.55 -1.6068E-04  3.9163E-04   3.0485E+00   1.6292E-04
        108.79   1265.84   1254.76     40.27       0.00     11.92     10.98     14.24 -1.3160E-04  3.3492E-04   2.9540E+00   1.3501E-04
        120.00   1399.38   1388.24     39.80       0.00     11.89     10.19     17.43 -1.0016E-04  2.9536E-04   2.8560E+00   1.1511E-04
        131.21   1532.62   1521.49     39.32       0.00     11.86      9.53     20.74 -7.2820E-05  2.6607E-04   2.7543E+00   1.0001E-04
        142.42   1665.70   1654.56     38.87       0.00     11.87      8.99     24.04 -5.0626E-05  2.4359E-04   2.6500E+00   8.8088E-05
        153.62   1798.66   1787.53     38.47       0.00     11.86      8.55     27.27 -3.3068E-05  2.2591E-04   2.5442E+00   7.8435E-05
        164.83   1931.55   1920.41     38.13       0.00     11.85      8.18     30.39 -1.9327E-05  2.1178E-04   2.4379E+00   7.0455E-05
        176.04   2064.38   2053.24     37.84       0.00     11.85      7.88     33.38 -8.6460E-06  2.0032E-04   2.3319E+00   6.3746E-05
        187.25   2197.17   2186.03     37.59       0.00     11.85      7.62     36.24 -4.0337E-07  1.9093E-04   2.2269E+00   5.8023E-05
        198.45   2329.93   2318.80     37.37       0.00     11.85      7.39     37.45  6.3187E-06  1.9042E-04   2.1235E+00   5.5181E-05
        209.66   2462.70   2451.56     37.17       0.00     11.85      7.18     38.58  1.2146E-05  1.9038E-04   2.0220E+00   5.2531E-05
        220.87   2595.46   2584.33     36.99       0.00     11.85      6.97     39.73  1.6975E-05  1.9034E-04   1.9225E+00   4.9935E-05
        232.08   2728.23   2717.09     36.84       0.00     11.85      6.77     40.90  2.0760E-05  1.9029E-04   1.8252E+00   4.7397E-05
        243.29   2860.99   2849.85     36.70       0.00     11.85      6.58     42.08  2.3506E-05  1.9025E-04   1.7302E+00   4.4920E-05
        254.49   2993.75   2982.62     36.59       0.00     11.85      6.41     43.26  2.5256E-05  1.9020E-04   1.6378E+00   4.2508E-05
        265.70   3126.52   3115.38     36.50       0.00     11.85      6.24     44.45  2.6078E-05  1.9015E-04   1.5479E+00   4.0164E-05
        276.91   3259.28   3248.15     36.43       0.00     11.85      6.08     45.62  2.6061E-05  1.9010E-04   1.4607E+00   3.7893E-05
        288.12   3392.05   3380.91     36.38       0.00     11.85      5.93     46.79  2.5305E-05  1.9005E-04   1.3764E+00   3.5696E-05
        299.32   3524.81   3513.67     36.34       0.00     11.85      5.79     47.95  2.3915E-05  1.8999E-04   1.2950E+00   3.3576E-05
        310.53   3657.57   3646.44     36.31       0.00     11.85      5.65     49.10  2.1998E-05  1.8994E-04   1.2167E+00   3.1536E-05
        321.74   3790.34   3779.20     36.30       0.00     11.85      5.53     50.24  1.9658E-05  1.8989E-04   1.1414E+00   2.9577E-05
        332.95   3923.10   3911.97     36.29       0.00     11.85      5.41     51.36  1.6995E-05  1.8983E-04   1.0693E+00   2.7700E-05
        344.15   4055.87   4044.73     36.29       0.00     11.85      5.29     52.47  1.4103E-05  1.8978E-04   1.0003E+00   2.5906E-05
        355.36   4188.63   4177.49     36.30       0.00     11.85      5.19     53.56  1.1069E-05  1.8972E-04   9.3448E-01   2.4193E-05
        366.57   4321.39   4310.26     36.31       0.00     11.85      5.09     54.63  7.9717E-06  1.8967E-04   8.7178E-01   2.2564E-05
        377.78   4454.16   4443.02     36.32       0.00     11.85      4.99     55.64  4.8799E-06  1.8961E-04   8.1219E-01   2.1015E-05
        388.99   4586.92   4575.78     36.34       0.00     11.85      4.90     56.73  1.8555E-06  1.8956E-04   7.5567E-01   1.9547E-05
        400.19   4719.68   4708.55     36.35       0.00     11.85      4.82     57.75 -1.0487E-06  1.8950E-04   7.0217E-01   1.8158E-05
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        422.61   4985.21   4974.07     36.38       0.00     11.85      4.66     59.75 -6.3253E-06  1.8939E-04   6.0396E-01   1.5609E-05
        433.82   5117.97   5106.84     36.39       0.00     11.85      4.59     60.72 -8.6314E-06  1.8933E-04   5.5909E-01   1.4445E-05
        445.02   5250.74   5239.60     36.39       0.00     11.85      4.52     61.67 -1.0684E-05  1.8928E-04   5.1692E-01   1.3352E-05
        456.23   5383.50   5372.36     36.40       0.00     11.85      4.45     62.61 -1.2465E-05  1.8922E-04   4.7737E-01   1.2327E-05
        467.44   5516.26   5505.13     36.40       0.00     11.85      4.39     63.53 -1.3966E-05  1.8917E-04   4.4033E-01   1.1367E-05
        478.65   5649.03   5637.89     36.39       0.00     11.85      4.33     64.43 -1.5181E-05  1.8912E-04   4.0570E-01   1.0470E-05
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        501.06   5914.55   5903.42     36.37       0.00     11.85      4.21     66.19 -1.6751E-05  1.8901E-04   3.4325E-01   8.8532E-06
        512.27   6047.32   6036.18     36.36       0.00     11.85      4.16     67.05 -1.7117E-05  1.8895E-04   3.1521E-01   8.1278E-06
        523.48   6180.08   6168.94     36.34       0.00     11.85      4.11     67.89 -1.7215E-05  1.8890E-04   2.8916E-01   7.4539E-06
        534.69   6312.84   6301.71     36.32       0.00     11.85      4.06     68.71 -1.7058E-05  1.8885E-04   2.6498E-01   6.8287E-06
        545.89   6445.61   6434.47     36.29       0.00     11.85      4.02     69.52 -1.6660E-05  1.8880E-04   2.4258E-01   6.2497E-06
        557.10   6578.37   6567.23     36.26       0.00     11.85      3.97     70.31 -1.6038E-05  1.8874E-04   2.2185E-01   5.7140E-06
        568.31   6711.13   6699.99     36.23       0.00     11.85      3.93     71.09 -1.5209E-05  1.8869E-04   2.0269E-01   5.2192E-06
        579.52   6843.89   6832.76     36.19       0.00     11.85      3.89     71.86 -1.4192E-05  1.8864E-04   1.8501E-01   4.7626E-06
        590.72   6976.66   6965.52     36.16       0.00     11.85      3.85     72.61 -1.3007E-05  1.8859E-04   1.6871E-01   4.3419E-06
        601.93   7109.42   7098.28     36.12       0.00     11.85      3.81     73.34 -1.1675E-05  1.8854E-04   1.5371E-01   3.9548E-06
        613.14   7242.18   7231.04     36.08       0.00     11.85      3.78     74.06 -1.0214E-05  1.8849E-04   1.3991E-01   3.5989E-06
        624.35   7374.94   7363.81     36.04       0.00     11.85      3.74     74.77 -8.6467E-06  1.8844E-04   1.2724E-01   3.2721E-06
        635.55   7507.71   7496.57     35.99       0.00     11.85      3.71     75.46 -6.9924E-06  1.8840E-04   1.1562E-01   2.9724E-06
        646.76   7640.47   7629.33     35.95       0.00     11.85      3.68     76.14 -5.2713E-06  1.8835E-04   1.0497E-01   2.6979E-06
        657.97   7773.23   7762.09     35.91       0.00     11.85      3.64     76.81 -3.5030E-06  1.8830E-04   9.5217E-02   2.4467E-06
        669.18   7905.99   7894.86     35.87       0.00     11.85      3.61     77.47 -1.7064E-06  1.8825E-04   8.6302E-02   2.2171E-06
        680.38   8038.76   8027.62     35.82       0.00     11.85      3.59     78.11  1.0014E-07  1.8821E-04   7.8160E-02   2.0074E-06
        691.59   8171.52   8160.38     35.78       0.00     11.85      3.56     78.74  1.8991E-06  1.8816E-04   7.0730E-02   1.8161E-06
        702.80   8304.28   8293.14     35.74       0.00     11.85      3.53     79.35  3.6738E-06  1.8812E-04   6.3957E-02   1.6418E-06
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 747.63  8835.33  8824.19  35.59   0.00   11.85   3.43   81.70  1.0231E-05  1.8794E-04  4.2444E-02  1.0886E-06
 758.84  8968.09  8956.96  35.56   0.00   11.85   3.41   82.26  1.1670E-05  1.8790E-04  3.8241E-02  9.8056E-07
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 781.25  9233.62  9222.48  35.50   0.00   11.85   3.37   83.35  1.4233E-05  1.8782E-04  3.0980E-02  7.9402E-07
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 826.08  9764.67  9753.53  35.42   0.00   11.85   3.29   85.38  1.7896E-05  1.8766E-04  2.0175E-02  5.1666E-07
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 848.50 10030.20 10019.06  35.40   0.00   11.85   3.25   86.34  1.8923E-05  1.8759E-04  1.6222E-02  4.1526E-07
 859.71 10162.96 10151.82  35.39   0.00   11.85   3.24   86.81  1.9228E-05  1.8755E-04  1.4533E-02  3.7196E-07
 870.92 10295.72 10284.58  35.38   0.00   11.85   3.22   87.26  1.9395E-05  1.8751E-04  1.3013E-02  3.3300E-07
 882.12 10428.48 10417.35  35.38   0.00   11.85   3.21   87.71  1.9424E-05  1.8748E-04  1.1646E-02  2.9795E-07
 893.33 10561.25 10550.11  35.38   0.00   11.85   3.19   88.15  1.9319E-05  1.8744E-04  1.0416E-02  2.6644E-07
 904.54 10694.01 10682.87  35.39   0.00   11.85   3.18   88.57  1.9081E-05  1.8741E-04  9.3119E-03  2.3815E-07
 915.75 10826.77 10815.64  35.39   0.00   11.85   3.16   88.99  1.8716E-05  1.8738E-04  8.3202E-03  2.1275E-07
 926.95 10959.54 10948.40  35.40   0.00   11.85   3.15   89.40  1.8228E-05  1.8734E-04  7.4303E-03  1.8996E-07
 938.16 11092.30 11081.16  35.41   0.00   11.85   3.13   89.80  1.7621E-05  1.8731E-04  6.6324E-03  1.6953E-07
 949.37 11225.06 11213.92  35.43   0.00   11.85   3.12   90.20  1.6903E-05  1.8728E-04  5.9172E-03  1.5122E-07
 960.58 11357.82 11346.69  35.44   0.00   11.85   3.11   90.58  1.6079E-05  1.8725E-04  5.2767E-03  1.3483E-07
 971.78 11490.59 11479.45  35.46   0.00   11.85   3.10   90.96  1.5157E-05  1.8722E-04  4.7033E-03  1.2016E-07
 982.99 11623.35 11612.21  35.48   0.00   11.85   3.08   91.33  1.4144E-05  1.8719E-04  4.1904E-03  1.0704E-07
 994.20 11756.11 11744.98  35.50   0.00   11.85   3.07   91.69  1.3048E-05  1.8716E-04  3.7317E-03  9.5307E-08
1005.41 11888.88 11877.74  35.53   0.00   11.85   3.06   92.04  1.1878E-05  1.8713E-04  3.3218E-03  8.4825E-08
1016.62 12021.64 12010.50  35.55   0.00   11.85   3.05   92.39  1.0641E-05  1.8710E-04  2.9557E-03  7.5464E-08
1027.82 12154.40 12143.27  35.58   0.00   11.85   3.04   92.72  9.3463E-06  1.8707E-04  2.6288E-03  6.7108E-08
1039.03 12287.17 12276.03  35.60   0.00   11.85   3.03   93.05  8.0031E-06  1.8704E-04  2.3371E-03  5.9653E-08
1050.24 12419.93 12408.79  35.63   0.00   11.85   3.02   93.38  6.6200E-06  1.8702E-04  2.0770E-03  5.3006E-08
1061. 5 12552.69 12541.56  35.66   0.00   11.85   3.01   93.69  5.2061E-06  1.8699E-04  1.8451E-03  4.7081E-08
1072.65 12685.46 12674.32  35.69   0.00   11.85   3.00   94.00  3.7704E-06  1.8696E-04  1.6385E-03  4.1803E-08
1083.86 12818.22 12807.08  35.71   0.00   11.85   2.99   94.31  2.3219E-06  1.8694E-04  1.4544E-03  3.7103E-08
1095.07 12950.98 12939.85  35.74   0.00   11.85   2.98   94.60  8.6948E-07  1.8691E-04  1.2906E-03  3.2919E-08
1106.28 13083.75 13072.61  35.77   0.00   11.85   2.97   94.89 -5.7815E-07  1.8689E-04  1.1448E-03  2.9197E-08
1117.49 13216.51 13205.37  35.80   0.00   11.85   2.96   95.18 -2.0124E-06  1.8686E-04  1.0152E-03  2.5887E-08
1128.69 13349.27 13338.13  35.83   0.00   11.85   2.96   95.45 -3.4249E-06  1.8684E-04  8.9989E-04  2.2944E-08
1139.90 13482.03 13470.90  35.86   0.00   11.85   2.95   95.72 -4.8074E-06  1.8682E-04  7.9743E-04  2.0329E-08
1151.11 13614.80 13603.66  35.88   0.00   11.85   2.94   95.99 -6.1522E-06  1.8679E-04  7.0641E-04  1.8007E-08
1162.32 13747.56 13736.42  35.91   0.00   11.85   2.93   96.25 -7.4517E-06  1.8677E-04  6.2559E-04  1.5945E-08
1173.52 13880.32 13869.19  35.93   0.00   11.85   2.92   96.50 -8.6986E-06  1.8675E-04  5.5383E-04  1.4114E-08
1184.73 14013.09 14001.95  35.96   0.00   11.85   2.92   96.75 -9.8863E-06  1.8673E-04  4.9017E-04  1.2490E-08
1195.94 14145.85 14134.71  35.98   0.00   11.85   2.91   96.99 -1.1008E-05  1.8671E-04  4.3369E-04  1.1050E-08
1207.15 14278.61 14267.48  36.00   0.00   11.85   2.90   97.22 -1.2059E-05  1.8669E-04  3.8361E-04  9.7727E-09
1218.35 14411.38 14400.24  36.02   0.00   11.85   2.90   97.45 -1.3033E-05  1.8667E-04  3.3921E-04  8.6408E-09
1229.56 14544.14 14533.00  36.04   0.00   11.85   2.89   97.68 -1.3925E-05  1.8665E-04  2.9988E-04  7.6379E-09
1240.77 14676.90 14665.77  36.05   0.00   11.85   2.88   97.90 -1.4731E-05  1.8663E-04  2.6503E-04  6.7497E-09
1251.98 14809.67 14798.53  36.07   0.00   11.85   2.88   98.11 -1.5447E-05  1.8661E-04  2.3417E-04  5.9631E-09
1263.18 14942.43 14931.29  36.08   0.00   11.85   2.87   98.32 -1.6069E-05  1.8659E-04  2.0685E-04  5.2669E-09
1274.39 15075.19 15064.06  36.09   0.00   11.85   2.87   98.53 -1.6597E-05  1.8657E-04  1.8267E-04  4.6509E-09
1285.60 15207.96 15196.82  36.10   0.00   11.85   2.86   98.73 -1.7026E-05  1.8656E-04  1.6128E-04  4.1059E-09
1296.81 15340.72 15329.58  36.11   0.00   11.85   2.86   98.92 -1.7355E-05  1.8654E-04  1.4236E-04  3.6239E-09
1308.02 15473.48 15462.35  36.11   0.00   11.85   2.85   99.12 -1.7584E-05  1.8652E-04  1.2563E-04  3.1977E-09
1319.22 15606.25 15595.11  36.11   0.00   11.85   2.85   99.30 -1.7713E-05  1.8650E-04  1.1084E-04  2.8211E-09
1330.43 15739.01 15727.87  36.12   0.00   11.85   2.84   99.48 -1.7740E-05  1.8649E-04  9.7773E-05  2.4882E-09
1341.64 15871.77 15860.63  36.11   0.00   11.85   2.84   99.66 -1.7667E-05  1.8647E-04  8.6226E-05  2.1942E-09
1352.85 16004.53 15993.40  36.11   0.00   11.85   2.83   99.83 -1.7496E-05  1.8646E-04  7.6027E-05  1.9345E-09
1364.05 16137.30 16126.16  36.10   0.00   11.85   2.83  100.00 -1.7227E-05  1.8644E-04  6.7020E-05  1.7051E-09
1375.26 16270.06 16258.92  36.10   0.00   11.85   2.82  100.17 -1.6863E-05  1.8643E-04  5.9068E-05  1.5027E-09
1386.47 16402.82 16391.69  36.09   0.00   11.85   2.82  100.33 -1.6406E-05  1.8641E-04  5.2050E-05  1.3241E-09
1397.68 16535.59 16524.45  36.08   0.00   11.85   2.81  100.49 -1.5860E-05  1.8640E-04  4.5857E-05  1.1664E-09
1408.88 16668.35 16657.21  36.07   0.00   11.85   2.81  100.64 -1.5229E-05  1.8639E-04  4.0393E-05  1.0274E-09
1420.09 16801.11 16789.98  36.05   0.00   11.85   2.81  100.79 -1.4516E-05  1.8637E-04  3.5573E-05  9.0474E-10
1431.30 16933.88 16922.74  36.03   0.00   11.85   2.80  100.93 -1.3726E-05  1.8636E-04  3.1324E-05  7.9660E-10
1442.51 17066.64 17055.50  36.02   0.00   11.85   2.80  101.08 -1.2863E-05  1.8635E-04  2.7577E-05  7.0126E-10
1476.13 17464.93 17453.79  35.96   0.00   11.85   2.79  101.48 -9.8907E-06  1.8631E-04  1.8799E-05  4.7794E-10
1487.34 17597.69 17586.55  35.94   0.00   11.85   2.78  101.61 -8.7911E-06  1.8630E-04  1.6539E-05  4.2048E-10
1498.55 17730.45 17719.32  35.91   0.00   11.85   2.78  101.73 -7.6470E-06  1.8629E-04  1.4549E-05  3.6986E-10
1509.75 17863.22 17852.08  35.89   0.00   11.85   2.78  101.86 -6.4647E-06  1.8628E-04  1.2797E-05  3.2529E-10
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LONG TERM DIFFUSION

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TIME  2.4711E+03SEC.  MEAN Y   92.213FT.  SOLID DENSITY2.600GM/CC  FALL VEL.  5.0000E-02FT/SEC TSS  3.1525E+01CUFT.
            SOLID IN SUSPENSION

        Y          X          Z         SIGMAX      SIGMAZ      SIGMAXZ     CONC.       C00
       0.0  0.           0.          0.          0.          0.          0.          5.4103E-17
       3.7  2.0758E+04   0.          3.2067E+06  6.6987E+03  0.          9.3876E-21  8.6449E-15
       7.3  2.0727E+04   0.          3.0303E+06  6.3361E+03  0.          1.6372E-19  1.4254E-13
      10.8  2.0675E+04   0.          2.7398E+06  5.8817E+03  0.          2.5184E-18  2.0087E-12
      14.2  2.0568E+04   0.          2.3727E+06  5.3916E+03  0.          3.6220E-17  2.5740E-11
      17.6  2.0384E+04   0.          2.0075E+06  4.9177E+03  0.          4.7668E-16  2.9759E-10
      20.9  2.0121E+04   0.          1.7005E+06  4.4938E+03  0.          5.5583E-15  3.0529E-09
      24.1  1.9838E+04   0.          1.4429E+06  4.1872E+03  0.          5.4257E-14  2.6498E-08
      27.2  1.9611E+04   0.          1.2365E+06  4.0377E+03  0.          4.0962E-13  1.8185E-07
      30.2  1.9458E+04   0.          1.0968E+06  4.0255E+03  0.          2.2570E-12  9.4232E-07
      33.2  1.9368E+04   0.          1.0216E+06  4.1163E+03  0.          9.2464E-12  3.7675E-06
      36.0  1.9322E+04   0.          1.0004E+06  4.2898E+03  0.          2.9586E-11  1.2178E-05
      38.8  1.9301E+04   0.          1.0161E+06  4.5194E+03  0.          7.8123E-11  3.3263E-05
      41.5  1.9286E+04   0.          1.0485E+06  4.7667E+03  0.          1.8202E-10  8.0855E-05
      44.1  1.9266E+04   0.          1.0837E+06  4.9916E+03  0.          3.9250E-10  1.8138E-04
      46.7  1.9244E+04   0.          1.1172E+06  5.1748E+03  0.          7.9859E-10  3.8151E-04
      49.1  1.9224E+04   0.          1.1514E+06  5.3207E+03  0.          1.5394E-09  7.5708E-04
      51.5  1.9207E+04   0.          1.1903E+06  5.4423E+03  0.          2.8097E-09  1.4209E-03
      53.8  1.9195E+04   0.          1.2358E+06  5.5509E+03  0.          4.8597E-09  2.5290E-03
      56.0  1.9187E+04   0.          1.2880E+06  5.6535E+03  0.          7.9936E-09  4.2860E-03
      58.2  1.9180E+04   0.          1.3461E+06  5.7531E+03  0.          1.2566E-08  6.9480E-03
      60.2  1.9174E+04   0.          1.4083E+06  5.8508E+03  0.          1.8976E-08  1.0822E-02
      62.2  1.9168E+04   0.          1.4732E+06  5.9463E+03  0.          2.7652E-08  1.6262E-02
      64.1  1.9162E+04   0.          1.5395E+06  6.0394E+03  0.          3.9041E-08  2.3653E-02
      65.9  1.9155E+04   0.          1.6061E+06  6.1295E+03  0.          5.3576E-08  3.3401E-02
      67.7  1.9149E+04   0.          1.6722E+06  6.2163E+03  0.          7.1655E-08  4.5903E-02
      69.3  1.9142E+04   0.          1.7371E+06  6.2994E+03  0.          9.3607E-08  6.1524E-02
      70.9  1.9135E+04   0.          1.8003E+06  6.3788E+03  0.          1.1966E-07  8.0571E-02
      72.4  1.9127E+04   0.          1.8614E+06  6.4542E+03  0.          1.4994E-07  1.0326E-01
      73.8  1.9120E+04   0.          1.9202E+06  6.5257E+03  0.          1.8439E-07  1.2969E-01
      75.1  1.9114E+04   0.          1.9766E+06  6.5932E+03  0.          2.2284E-07  1.5984E-01
      76.3  1.9107E+04   0.          2.0303E+06  6.6569E+03  0.          2.6498E-07  1.9356E-01
      77.6  1.9101E+04   0.          2.0859E+06  6.7220E+03  0.          3.1401E-07  2.3363E-01
      78.8  1.9094E+04   0.          2.1436E+06  6.7888E+03  0.          3.7090E-07  2.8113E-01
      80.1  1.9087E+04   0.          2.2034E+06  6.8574E+03  0.          4.3664E-07  3.3723E-01
      81.3  1.9081E+04   0.          2.2655E+06  6.9280E+03  0.          5.1228E-07  4.0324E-01
      82.6  1.9075E+04   0.          2.3299E+06  7.0006E+03  0.          5.9887E-07  4.8056E-01
      83.8  1.9069E+04   0.          2.3966E+06  7.0752E+03  0.          6.9745E-07  5.7064E-01
      85.1  1.9064E+04   0.          2.4655E+06  7.1516E+03  0.          8.0899E-07  6.7496E-01
      86.3  1.9060E+04   0.          2.5364E+06  7.2298E+03  0.          9.3429E-07  7.9494E-01
      87.5  1.9056E+04   0.          2.6092E+06  7.3096E+03  0.          1.0740E-06  9.3195E-01
      88.8  1.9053E+04   0.          2.6837E+06  7.3909E+03  0.          1.2287E-06  1.0873E+00
      90.0  1.9052E+04   0.          2.7598E+06  7.4736E+03  0.          1.3986E-06  1.2621E+00
      91.3  1.9051E+04   0.          2.8375E+06  7.5577E+03  0.          1.5839E-06  1.4574E+00
      92.5  1.9051E+04   0.          2.9165E+06  7.6431E+03  0.          1.7845E-06  1.6740E+00
      93.8  1.9052E+04   0.          2.9970E+06  7.7297E+03  0.          2.0001E-06  1.9128E+00
      95.0  1.9055E+04   0.          3.0787E+06  7.8177E+03  0.          2.2302E-06  2.1740E+00
      96.3  1.9058E+04   0.          3.1616E+06  7.9068E+03  0.          2.4741E-06  2.4578E+00
      97.5  1.9063E+04   0.          3.2456E+06  7.9971E+03  0.          2.7306E-06  2.7641E+00
      98.8  1.9069E+04   0.          3.3303E+06  8.0882E+03  0.          2.9984E-06  3.0920E+00
     100.0  1.9076E+04   0.          3.4116E+06  8.1758E+03  0.          3.2655E-06  3.4266E+00

            SOLID ON THE BED

                   X          Z         SIGMAX      SIGMAZ      SIGMAXZ      DEPOSITED SOLID
              2.0201E+04  0.           4.8414E+06  5.3988E+03  0.            6.0441E+02
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Section 2. Blake Island Pipeline Discharge

```
 AMBIENT CONDITIONS
DEPTH IN FT.  DENSITY IN GRAM PER CC.  KY IN SQFT PER SEC.  VEL. IN FPS.
DEPTH              .0             .250000E+03
AMB-DENSITY        .1020E+01     .1023E+01


YK                   .2000E+02    .3000E+02    .6000E+02    .7000E+02
KY                   .5000E-01    .5000E-02    .5000E-01

YU  .1000E+03YW   .2000E+02YE   .1500E+03H   .2400E+03
UA  .5000E+00WA   .0


BARGE OPERATION 2
DISCHARGE THROUGH A NOZZLE UNDER A MOVING BARGE

TSTOP   .2000E+05SEC.

GRID POINT SIZE   51 KEY1    1 KEY2    3 KEY3    1

USE TETRA TECH SUGGESTED COEFFICIENTS

DINCR1    1.0000 DINCR2    1.0000
ALPHA1      .0806  ALPHA2      .3536  BETA       .0000 CD      1.3000
GAMA  .25 CDRAG 1.00 CFRIC .010 CD3  .20 CD4 2.00 ALPHA3      .3536
ALPHA4      .0610 FRICTN      .0100 F1      .1000 CM     1.0000
ALFA1     1.0000 ALFA2     1.0000 GAMA1      .0000 GAMA2      .0000
ALAMDA      .0010

JET RADIUS        .6700  DENSITY     1.3300  ANGLE OF JET    90.0000
VELOCITY   14.3000 AT    20.0000 FT.
       K    1  L    2
DENSITY OF SOLID              .2650E+01
CONCENTRATION                 .1000E+00    .1000E+00
FALL VELOCITY OF SOLID        .1000E-01    .2000E+00
BARGE VELOCITY       .0100 ANGLE WITH X-AXIS  180.0000 DEGREES FOR .1200E+04 SEC.

AMBIENT CURRENT FOR A MOVING COORDINATE FIXED ON THE BARGE
      0        YU        YW        YE        H
    .5100    .5100               .0100    .0100
   -.0000              .0000   -.0000   -.0000
 JET CONVECTION

  1  .1000E+01   .6700E+00   1   0   41

  2  .2929E+00   .6700E+00   1   0   83

  3  .1736E+00   .6700E+00   1   0  124
       T       S       X       Y       Z       U  RADIUS     DEN-DIF FLUID CONC.FLUX OF SOLID CONCENTRATION
     .00     .00     .00   20.00     .00  14.300    .670   .3098E+00   .8000E+00   .2017E+01   .1000E+00
                                                                                   .2017E+01   .1000E+00
     .02     .27     .24   20.00     .00  13.724    .703   .2927E+00   .7572E+00   .2017E+01   .9465E-01
                                                                                   .2010E+01   .9434E-01
     .04     .59     .54   20.01     .00  13.085    .743   .2744E+00   .7107E+00   .2017E+01   .8883E-01
                                                                                   .2006E+01   .8835E-01
     .07     .99     .90   20.02     .00  12.386    .792   .2552E+00   .6610E+00   .2017E+01   .8262E-01
                                                                                   .2006E+01   .8218E-01
     .11    1.46    1.33   20.03     .00  11.636    .851   .2351E+00   .6089E+00   .2017E+01   .7611E-01
                                                                                   .2006E+01   .7570E-01
     .16    2.04    1.85   20.07     .00  10.844    .923   .2144E+00   .5553E+00   .2017E+01   .6942E-01
                                                                                   .2006E+01   .6904E-01
     .23    2.74    2.48   20.13     .00  10.025   1.011   .1935E+00   .5012E+00   .2017E+01   .6265E-01
                                                                                   .2006E+01   .6231E-01
     .31    3.58    3.24   20.23     .00   9.199   1.117   .1727E+00   .4474E+00   .2017E+01   .5592E-01
                                                                                   .2006E+01   .5562E-01
     .43    4.60    4.16   20.39     .00   8.387   1.245   .1524E+00   .3948E+00   .2017E+01   .4935E-01
                                                                                   .2006E+01   .4909E-01
     .58    5.83    5.25   20.64     .00   7.613   1.400   .1329E+00   .3443E+00   .2017E+01   .4303E-01
                                                                                   .2006E+01   .4280E-01
     .78    7.33    6.54   21.05     .00   6.904   1.584   .1144E+00   .2963E+00   .2017E+01   .3704E-01
                                                                                   .2006E+01   .3684E-01
    1.05    9.14    8.06   21.69     .00   6.285   1.803   .9704E-01   .2514E+00   .2017E+01   .3142E-01
                                                                                   .2006E+01   .3125E-01
    1.41   11.32    9.80   22.66     .00   5.775   2.058   .8104E-01   .2100E+00   .2017E+01   .2624E-01
                                                                                   .2006E+01   .2610E-01
    1.87   13.97   11.74   24.07     .00   5.379   2.353   .6656E-01   .1725E+00   .2017E+01   .2156E-01
                                                                                   .2006E+01   .2144E-01
    2.48   17.17   13.86   26.06     .00   5.083   2.692   .5379E-01   .1394E+00   .2017E+01   .1743E-01
                                                                                   .2006E+01   .1734E-01
    3.25   21.05   16.13   28.76     .00   4.860   3.085   .4281E-01   .1111E+00   .2017E+01   .1388E-01
                                                                                   .2006E+01   .1381E-01
    4.20   25.61   18.51   32.29     .00   4.676   3.546   .3363E-01   .8735E-01   .2017E+01   .1092E-01
                                                                                   .2006E+01   .1086E-01
    5.20   30.26   20.78   36.35     .00   4.522   4.042   .2672E-01   .6952E-01   .2017E+01   .8690E-02
                                                                                   .2006E+01   .8643E-02
    6.24   34.91   22.80   40.54     .00   4.391   4.535   .2182E-01   .5687E-01   .2017E+01   .7109E-02
                                                                                   .2006E+01   .7071E-02
    7.30   39.57   24.64   44.82     .00   4.273   5.027   .1819E-01   .4755E-01   .2017E+01   .5943E-02
                                                                                   .2006E+01   .5911E-02
    8.40   44.22   26.34   49.15     .00   4.165   5.521   .1543E-01   .4045E-01   .2017E+01   .5056E-02
                                                                                   .2006E+01   .5029E-02
    9.52   48.87   27.93   53.52     .00   4.065   6.016   .1326E-01   .3490E-01   .2017E+01   .4363E-02
                                                                                   .2006E+01   .4339E-02
   10.68   53.53   29.45   57.92     .00   3.972   6.513   .1154E-01   .3048E-01   .2017E+01   .3810E-02
                                                                                   .2006E+01   .3790E-02
   11.85   58.18   30.90   62.34     .00   3.884   7.011   .1013E-01   .2690E-01   .2017E+01   .3362E-02
                                                                                   .2006E+01   .3344E-02
   13.06   62.83   32.31   66.77     .00   3.802   7.512   .8963E-02   .2394E-01   .2017E+01   .2992E-02
                                                                                   .2006E+01   .2976E-02
   14.29   67.49   33.68   71.22     .00   3.724   8.015   .7987E-02   .2147E-01   .2017E+01   .2683E-02
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15.54	72.14	35.02	75.67	.00	3.651	8.520	.7159E-02	.1938E-01	.2017E+01 .2006E+01	.2422E-02 .2409E-02
16.83	76.79	36.34	80.14	.00	3.581	9.028	.6450E-02	.1760E-01	.2017E+01 .2006E+01	.2199E-02 .2188E-02
18.13	81.44	37.64	84.60	.00	3.514	9.539	.5836E-02	.1606E-01	.2017E+01 .2006E+01	.2008E-02 .1997E-02
19.46	86.10	38.93	89.08	.00	3.451	10.052	.5301E-02	.1473E-01	.2017E+01 .2006E+01	.1841E-02 .1831E-02
20.82	90.75	40.20	93.55	.00	3.390	10.569	.4830E-02	.1356E-01	.2017E+01 .2006E+01	.1696E-02 .1686E-02
22.19	95.40	41.47	98.03	.00	3.331	11.088	.4414E-02	.1254E-01	.2017E+01 .2006E+01	.1567E-02 .1559E-02
23.60	100.06	42.74	102.50	.00	3.274	11.610	.4043E-02	.1163E-01	.2017E+01 .2006E+01	.1454E-02 .1446E-02
25.02	104.71	44.00	106.98	.00	3.221	12.129	.3714E-02	.1084E-01	.2017E+01 .2006E+01	.1355E-02 .1347E-02
26.47	109.36	45.25	111.46	.00	3.171	12.644	.3420E-02	.1013E-01	.2017E+01 .2006E+01	.1266E-02 .1259E-02
27.95	114.02	46.49	115.95	.00	3.124	13.154	.3155E-02	.9501E-02	.2017E+01 .2006E+01	.1188E-02 .1181E-02
29.44	118.67	47.71	120.44	.00	3.078	13.661	.2916E-02	.8939E-02	.2017E+01 .2006E+01	.1117E-02 .1111E-02
30.96	123.32	48.90	124.94	.00	3.035	14.163	.2699E-02	.8435E-02	.2017E+01 .2006E+01	.1054E-02 .1049E-02
32.50	127.98	50.08	129.44	.00	2.994	14.661	.2501E-02	.7980E-02	.2017E+01 .2006E+01	.9975E-03 .9921E-03
34.06	132.63	51.22	133.95	.00	2.954	15.155	.2320E-02	.7569E-02	.2017E+01 .2006E+01	.9461E-03 .9410E-03
35.64	137.28	52.34	138.47	.00	2.916	15.645	.2152E-02	.7195E-02	.2017E+01 .2006E+01	.8994E-03 .8945E-03
37.24	141.94	53.43	142.99	.00	2.879	16.132	.1997E-02	.6854E-02	.2017E+01 .2006E+01	.8568E-03 .8522E-03
38.86	146.59	54.49	147.52	.00	2.842	16.617	.1854E-02	.6543E-02	.2017E+01 .2006E+01	.8179E-03 .8135E-03
40.50	151.24	55.52	152.06	.00	2.807	17.100	.1719E-02	.6257E-02	.2017E+01 .2006E+01	.7821E-03 .7779E-03
42.17	155.89	56.52	156.60	.00	2.771	17.587	.1593E-02	.5992E-02	.2017E+01 .2006E+01	.7489E-03 .7449E-03
43.85	160.55	57.49	161.15	.00	2.735	18.080	.1474E-02	.5744E-02	.2017E+01 .2006E+01	.7180E-03 .7141E-03
45.56	165.20	58.43	165.71	.00	2.699	18.579	.1361E-02	.5513E-02	.2017E+01 .2006E+01	.6892E-03 .6854E-03
47.29	169.85	59.35	170.27	.00	2.662	19.084	.1254E-02	.5297E-02	.2017E+01 .2006E+01	.6622E-03 .6586E-03
49.04	174.51	60.24	174.84	.00	2.624	19.596	.1152E-02	.5095E-02	.2017E+01 .2006E+01	.6369E-03 .6335E-03
50.82	179.16	61.12	179.41	.00	2.587	20.115	.1056E-02	.4906E-02	.2017E+01 .2006E+01	.6133E-03 .6099E-03
52.63	183.81	61.97	183.98	.00	2.549	20.642	.9636E-03	.4728E-02	.2017E+01 .2006E+01	.5910E-03 .5878E-03
54.46	188.47	62.81	188.56	.00	2.510	21.177	.8756E-03	.4561E-02	.2017E+01 .2006E+01	.5702E-03 .5671E-03
56.32	193.12	63.63	193.14	.00	2.471	21.721	.7914E-03	.4404E-02	.2017E+01 .2006E+01	.5505E-03 .5475E-03
58.21	197.77	64.44	197.72	.00	2.432	22.274	.7108E-03	.4256E-02	.2017E+01 .2006E+01	.5320E-03 .5291E-03
60.13	202.43	65.24	202.31	.00	2.392	22.838	.6333E-03	.4117E-02	.2017E+01 .2006E+01	.5146E-03 .5118E-03
62.08	207.08	66.02	206.89	.00	2.351	23.412	.5589E-03	.3985E-02	.2017E+01 .2006E+01	.4981E-03 .4954E-03
64.07	211.73	66.79	211.48	.00	2.310	23.999	.4873E-03	.3861E-02	.2017E+01 .2006E+01	.4826E-03 .4800E-03
66.10	216.38	67.55	216.07	.00	2.267	24.599	.4182E-03	.3743E-02	.2017E+01 .2006E+01	.4679E-03 .4653E-03
68.16	221.04	68.31	220.66	.00	2.224	25.213	.3515E-03	.3632E-02	.2017E+01	.4539E-03
70.26	225.69	69.05	225.26	.00	2.181	25.843	.2870E-03	.3526E-02	.2017E+01 .2006E+01	.4408E-03 .4384E-03
72.41	230.34	69.80	229.85	.00	2.136	26.491	.2245E-03	.3426E-02	.2017E+01 .2006E+01	.4283E-03 .4260E-03
74.60	235.00	70.53	234.44	.00	2.090	27.159	.1639E-03	.3332E-02	.2017E+01 .2006E+01	.4164E-03 .4142E-03

Section 3. New Haven Instantaneous Bottom Dump

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  AMBIENT CONDITIONS
 DEPTH IN FT.  DENSITY IN GRAM PER CC.  KY IN SQFT PER SEC.  VEL. IN FPS.
 DEPTH           0.          8.0000E+01
 AMB-DENSITY     1.0180E+00  1.0200E+00

 YK               5.0000E+01  5.0000E+01  5.0000E+01  5.0000E+01
 KY               2.0000E-03  2.0000E-03  2.0000E-03

 YU 3.0000E+01YW 3.0000E+01YE 1.0000E+02H 7.0000E+01
 UA 1.0000E+00WA 0.


 BARGE OPERATION 1

 WASTE MATERIAL DUMPED INSTANTANEOUSLY INTO THE OCEAN

 THE SHAPE OF THE CLOUD IS ASSUMED TO BE HEMISPHERE

 TSTOP  1.8000E+03SEC.

 GRID POINT SIZE   51 KEY1    2 KEY2    2 KEY3    0

 USE READ IN COEFFICIENTS

 DINCR1     1.0000 DINCR2     5.0000
 ALPHA0      .2350 BETA     0.0000 CM     1.0000 CD      .5000
 GAMA  .25 CDRAG 1.00 CFRIC .010 CD3  .10 CD4 1.00 ALPHAC      .0010
 FRICTN      .0100 F1       .1000
 ALFA1    1.0000 ALFA2     1.0000 GAMA1     0.0000 GAMA2     0.0000
 ALAMDA      .0010

 RB  1.0240E+01 ROO  1.4800E+00 U  0.          V  6.0000E+00 W  0.
       K     1  L     1
 DENSITY OF SOLID          2.6500E+00
 CONCENTRATION
                           2.9000E-01
 FALL VELOCITY OF SOLID
                           1.0000E-02
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     CONVECTIVE DESCENT

     1  2.8434E-02     1      0   289

     2  5.4783E-02     1      0   151

  TIME       X         Y          Z       U       V       W       DEN-DIF     RADIUS  VORT.   ALPHA   FLUID CONC.  SOLID-VOL.   CONCENTRATION
  0.00      0.00      0.00       0.00    0.00   6.000   0.00   4.6199E-01   10.24   61.44   .2350   7.1000E-01   6.5216E+02   2.9000E-01
   .11       .00       .70       0.00     .04   6.755   0.00   4.4016E-01   10.41   61.41   .2350   6.7649E-01   6.5216E+02   2.7631E-01
   .22       .01      1.48       0.00     .09   7.399   0.00   4.1759E-01   10.59   61.38   .2350   6.4183E-01   6.5216E+02   2.6215E-01
   .33       .02      2.32       0.00     .13   7.936   0.00   3.9489E-01   10.79   61.35   .2350   6.0697E-01   6.5216E+02   2.4792E-01
   .44       .04      3.21       0.00     .18   8.373   0.00   3.7255E-01   11.00   61.32   .2350   5.7266E-01   6.5216E+02   2.3390E-01
   .55       .06      4.15       0.00     .22   8.720   0.00   3.5093E-01   11.22   61.29   .2350   5.3946E-01   6.5216E+02   2.2034E-01
   .66       .09      5.12       0.00     .26   8.988   0.00   3.3027E-01   11.45   61.26   .2350   5.0774E-01   6.5216E+02   2.0739E-01
   .77       .12      6.12       0.00     .31   9.187   0.00   3.1073E-01   11.69   61.22   .2350   4.7774E-01   6.5216E+02   1.9513E-01
   .88       .15      7.13       0.00     .35   9.328   0.00   2.9239E-01   11.92   61.19   .2350   4.4958E-01   6.5216E+02   1.8363E-01
   .99       .19      8.16       0.00     .38   9.419   0.00   2.7526E-01   12.17   61.15   .2350   4.2328E-01   6.5216E+02   1.7289E-01
  1.10       .24      9.19       0.00     .42   9.471   0.00   2.5934E-01   12.41   61.11   .2350   3.9883E-01   6.5216E+02   1.6290E-01
  1.21       .28     10.23       0.00     .45   9.488   0.00   2.4456E-01   12.66   61.07   .2350   3.7615E-01   6.5216E+02   1.5364E-01
  1.31       .34     11.27       0.00     .48   9.479   0.00   2.3089E-01   12.90   61.03   .2350   3.5515E-01   6.5216E+02   1.4506E-01
  1.42       .39     12.31       0.00     .51   9.448   0.00   2.1824E-01   13.14   60.98   .2350   3.3573E-01   6.5216E+02   1.3713E-01
  1.53       .45     13.34       0.00     .54   9.400   0.00   2.0654E-01   13.39   60.94   .2350   3.1778E-01   6.5216E+02   1.2980E-01
  1.64       .51     14.37       0.00     .57   9.339   0.00   1.9573E-01   13.63   60.89   .2350   3.0118E-01   6.5216E+02   1.2302E-01
  1.75       .57     15.39       0.00     .59   9.267   0.00   1.8572E-01   13.87   60.84   .2350   2.8583E-01   6.5216E+02   1.1675E-01
  1.86       .64     16.40       0.00     .61   9.187   0.00   1.7646E-01   14.11   60.79   .2350   2.7161E-01   6.5216E+02   1.1094E-01
  1.97       .71     17.40       0.00     .63   9.102   0.00   1.6788E-01   14.34   60.74   .2350   2.5844E-01   6.5216E+02   1.0556E-01
  2.08       .78     18.39       0.00     .65   9.012   0.00   1.5992E-01   14.57   60.68   .2350   2.4622E-01   6.5216E+02   1.0057E-01
  2.19       .85     19.38       0.00     .67   8.919   0.00   1.5253E-01   14.81   60.63   .2350   2.3488E-01   6.5216E+02   9.5936E-02
  2.30       .92     20.35       0.00     .68   8.825   0.00   1.4565E-01   15.03   60.57   .2350   2.2433E-01   6.5216E+02   9.1626E-02
  2.41      1.00     21.31       0.00     .70   8.729   0.00   1.3925E-01   15.26   60.51   .2350   2.1450E-01   6.5216E+02   8.7613E-02
  2.52      1.08     22.26       0.00     .71   8.633   0.00   1.3326E-01   15.48   60.45   .2350   2.0534E-01   6.5216E+02   8.3871E-02
  2.63      1.16     23.20       0.00     .73   8.538   0.00   1.2770E-01   15.71   60.38   .2350   1.9679E-01   6.5216E+02   8.0378E-02
  2.74      1.24     24.13       0.00     .74   8.443   0.00   1.2249E-01   15.92   60.32   .2350   1.8879E-01   6.5216E+02   7.7111E-02
  2.85      1.32     25.05       0.00     .75   8.349   0.00   1.1761E-01   16.14   60.25   .2350   1.8130E-01   6.5216E+02   7.4052E-02
  2.96      1.40     25.96       0.00     .76   8.257   0.00   1.1303E-01   16.35   60.18   .2350   1.7428E-01   6.5216E+02   7.1185E-02
  3.07      1.49     26.86       0.00     .77   8.166   0.00   1.0874E-01   16.57   60.11   .2350   1.6769E-01   6.5216E+02   6.8493E-02
  3.18      1.57     27.75       0.00     .78   8.076   0.00   1.0470E-01   16.78   60.04   .2350   1.6149E-01   6.5216E+02   6.5963E-02
  3.29      1.66     28.63       0.00     .79   7.989   0.00   1.0090E-01   16.98   59.97   .2350   1.5566E-01   6.5216E+02   6.3581E-02
  3.40      1.74     29.50       0.00     .80   7.903   0.00   9.7314E-02   17.19   59.89   .2350   1.5017E-01   6.5216E+02   6.1337E-02
  3.51      1.83     30.36       0.00     .81   7.819   0.00   9.3933E-02   17.39   59.81   .2350   1.4499E-01   6.5216E+02   5.9219E-02
  3.62      1.92     31.21       0.00     .81   7.736   0.00   9.0740E-02   17.59   59.73   .2350   1.4009E-01   6.5216E+02   5.7219E-02
  3.73      2.01     32.06       0.00     .82   7.656   0.00   8.7720E-02   17.79   59.65   .2350   1.3546E-01   6.5216E+02   5.5328E-02
  3.83      2.10     32.89       0.00     .83   7.578   0.00   8.4860E-02   17.98   59.57   .2350   1.3107E-01   6.5216E+02   5.3537E-02
  3.94      2.19     33.72       0.00     .83   7.501   0.00   8.2150E-02   18.18   59.48   .2350   1.2692E-01   6.5216E+02   5.1840E-02
  4.05      2.28     34.54       0.00     .84   7.426   0.00   7.9578E-02   18.37   59.40   .2350   1.2298E-01   6.5216E+02   5.0230E-02
  4.16      2.37     35.35       0.00     .84   7.353   0.00   7.7136E-02   18.56   59.31   .2350   1.1923E-01   6.5216E+02   4.8701E-02
  4.27      2.47     36.15       0.00     .84   7.282   0.00   7.4814E-02   18.75   59.22   .2350   1.1567E-01   6.5216E+02   4.7247E-02
  4.38      2.56     36.94       0.00     .84   7.212   0.00   7.2604E-02   18.94   59.13   .2350   1.1229E-01   6.5216E+02   4.5864E-02
  4.49      2.65     37.73       0.00     .85   7.144   0.00   7.0499E-02   19.12   59.03   .2350   1.0906E-01   6.5216E+02   4.4547E-02
  4.60      2.74     38.51       0.00     .85   7.078   0.00   6.8493E-02   19.30   58.94   .2350   1.0599E-01   6.5216E+02   4.3291E-02
  4.71      2.84     39.28       0.00     .85   7.013   0.00   6.6579E-02   19.48   58.84   .2350   1.0306E-01   6.5216E+02   4.2093E-02
  4.82      2.93     40.04       0.00     .85   6.950   0.00   6.4751E-02   19.66   58.74   .2350   1.0026E-01   6.5216E+02   4.0949E-02
  4.93      3.02     40.80       0.00     .85   6.888   0.00   6.3004E-02   19.84   58.64   .2350   9.7579E-02   6.5216E+02   3.9856E-02
  5.04      3.12     41.55       0.00     .85   6.828   0.00   6.1333E-02   20.02   58.53   .2350   9.5020E-02   6.5216E+02   3.8811E-02
  5.15      3.21     42.30       0.00     .85   6.769   0.00   5.9733E-02   20.19   58.43   .2350   9.2570E-02   6.5216E+02   3.7810E-02
  5.26      3.30     43.04       0.00     .85   6.711   0.00   5.8201E-02   20.37   58.32   .2350   9.0224E-02   6.5216E+02   3.6852E-02
  5.92      3.85     47.34       0.00     .84   6.392   0.00   5.0224E-02   21.38   57.64   .2350   7.8013E-02   6.5216E+02   3.1864E-02
  6.03      3.95     48.04       0.00     .83   6.342   0.00   4.9068E-02   21.54   57.52   .2350   7.6245E-02   6.5216E+02   3.1142E-02
  6.14      4.04     48.73       0.00     .83   6.294   0.00   4.7956E-02   21.71   57.40   .2350   7.4544E-02   6.5216E+02   3.0447E-02
  6.25      4.13     49.42       0.00     .83   6.247   0.00   4.6885E-02   21.87   57.28   .2350   7.2905E-02   6.5216E+02   2.9778E-02
  6.35      4.22     50.10       0.00     .83   6.201   0.00   4.5852E-02   22.03   57.15   .2350   7.1325E-02   6.5216E+02   2.9133E-02
  6.46      4.31     50.78       0.00     .82   6.155   0.00   4.4856E-02   22.19   57.03   .2350   6.9801E-02   6.5216E+02   2.8510E-02
  6.57      4.40     51.45       0.00     .82   6.111   0.00   4.3895E-02   22.34   56.90   .2350   6.8332E-02   6.5216E+02   2.7910E-02
  6.68      4.49     52.12       0.00     .82   6.067   0.00   4.2967E-02   22.50   56.77   .2350   6.6913E-02   6.5216E+02   2.7331E-02
  6.79      4.58     52.78       0.00     .81   6.025   0.00   4.2071E-02   22.66   56.63   .2350   6.5543E-02   6.5216E+02   2.6771E-02
  6.90      4.67     53.44       0.00     .81   5.983   0.00   4.1205E-02   22.81   56.50   .2350   6.4219E-02   6.5216E+02   2.6230E-02
  7.01      4.76     54.09       0.00     .81   5.942   0.00   4.0367E-02   22.97   56.36   .2350   6.2939E-02   6.5216E+02   2.5708E-02
  7.12      4.84     54.74       0.00     .80   5.902   0.00   3.9558E-02   23.12   56.22   .2350   6.1702E-02   6.5216E+02   2.5202E-02
  7.23      4.93     55.38       0.00     .80   5.862   0.00   3.8774E-02   23.27   56.08   .2350   6.0505E-02   6.5216E+02   2.4713E-02
  7.34      5.02     56.02       0.00     .79   5.823   0.00   3.8016E-02   23.42   55.94   .2350   5.9346E-02   6.5216E+02   2.4240E-02
  7.45      5.11     56.66       0.00     .79   5.785   0.00   3.7281E-02   23.57   55.80   .2350   5.8223E-02   6.5216E+02   2.3781E-02
  7.56      5.19     57.29       0.00     .79   5.748   0.00   3.6569E-02   23.72   55.65   .2350   5.7136E-02   6.5216E+02   2.3337E-02
  7.67      5.28     57.92       0.00     .78   5.711   0.00   3.5879E-02   23.87   55.51   .2350   5.6083E-02   6.5216E+02   2.2907E-02
  7.78      5.36     58.54       0.00     .78   5.675   0.00   3.5211E-02   24.01   55.36   .2350   5.5061E-02   6.5216E+02   2.2490E-02
  7.89      5.45     59.16       0.00     .77   5.640   0.00   3.4562E-02   24.16   55.21   .2350   5.4071E-02   6.5216E+02   2.2085E-02
  8.00      5.53     59.78       0.00     .77   5.605   0.00   3.3932E-02   24.30   55.05   .2350   5.3110E-02   6.5216E+02   2.1693E-02
  8.11      5.62     60.39       0.00     .77   5.571   0.00   3.3321E-02   24.45   54.90   .2350   5.2177E-02   6.5216E+02   2.1312E-02
  8.22      5.70     61.00       0.00     .76   5.537   0.00   3.2728E-02   24.59   54.74   .2350   5.1271E-02   6.5216E+02   2.0942E-02
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      COLLAPSE PHASE
  1  5.4783E-02     1     0  599
  2  4.9086E-01     1     0  599
  3  4.3981E+00     4     3  272

TIME          X          Y          Z        U      V      W      DEN-DIF       A       B          FLUID CONC.   SOLID-VOL.   CONCENTRATION
     8.22       5.70     61.00 0.                .76  5.537  0.00  3.2728E-02  12.30   24.59      5.1271E-02   6.5216E+02   2.0942E-02
    12.62       8.89     70.91 0.                .70   .256  0.00  2.4383E-02   4.90   44.89      3.8562E-02   6.5216E+02   1.5750E-02
    17.01      11.78     71.73 0.                .62   .136  0.00  2.2938E-02   3.82   52.44      3.6308E-02   6.5216E+02   1.4830E-02
    21.41      14.40     72.20 0.                .57   .085  0.00  2.1759E-02   3.19   58.88      3.4460E-02   6.5216E+02   1.4075E-02
    25.81      16.84     72.52 0.                .54   .059  0.00  2.0735E-02   2.78   64.63      3.2850E-02   6.5216E+02   1.3418E-02
    30.21      19.12     72.74 0.                .50   .043  0.00  1.9865E-02   2.48   69.81      3.1480E-02   6.5216E+02   1.2858E-02
    34.61      21.27     72.90 0.                .47   .033  0.00  1.9151E-02   2.26   74.46      3.0355E-02   6.5216E+02   1.2399E-02
    39.00      23.29     73.03 0.                .45   .026  0.00  1.8594E-02   2.09   78.61      2.9477E-02   6.5216E+02   1.2040E-02
    43.40      25.19     73.14 0.                .42   .022  0.00  1.8193E-02   1.95   82.27      2.8846E-02   6.5216E+02   1.1782E-02
    47.80      26.98     73.23 0.                .39   .018  0.00  1.7941E-02   1.84   85.44      2.8450E-02   6.5216E+02   1.1620E-02
    52.20      28.66     73.30 0.                .37   .016  0.00  1.7778E-02   1.74   88.27      2.8194E-02   6.5216E+02   1.1516E-02
    56.60      30.23     73.37 0.                .35   .014  0.00  1.7531E-02   1.65   91.18      2.7805E-02   6.5216E+02   1.1357E-02
    60.99      31.70     73.42 0.                .32   .012  0.00  1.7115E-02   1.57   94.42      2.7148E-02   6.5216E+02   1.1089E-02
    65.39      33.08     73.47 0.                .30   .010  0.00  1.6525E-02   1.51   98.07      2.6214E-02   6.5216E+02   1.0707E-02
    69.79      34.37     73.51 0.                .28   .008  0.00  1.5478E-02   1.46   102.1      2.5041E-02   6.4015E+02   1.0040E-02
    74.19      35.59     73.55 0.                .27   .007  0.00  1.4286E-02   1.42   106.6      2.3683E-02   6.2562E+02   9.2797E-03
    78.59      36.74     73.57 0.                .26   .006  0.00  1.3064E-02   1.38   111.6      2.2207E-02   6.1101E+02   8.4979E-03
    82.99      37.86     73.60 0.                .25   .005  0.00  1.1855E-02   1.35   117.0      2.0677E-02   5.9639E+02   7.7233E-03
    87.38      38.94     73.62 0.                .24   .004  0.00  1.0694E-02   1.32   122.7      1.9151E-02   5.8183E+02   6.9786E-03
    91.78      40.00     73.64 0.                .24   .003  0.00  9.6066E-03   1.30   128.8      1.7670E-02   5.6738E+02   6.2792E-03
    96.18      41.06     73.65 0.                .24   .003  0.00  8.6052E-03   1.28   135.1      1.6266E-02   5.5308E+02   5.6344E-03
   100.58      42.11     73.66 0.                .24   .002  0.00  7.6958E-03   1.27   141.7      1.4955E-02   5.3897E+02   5.0480E-03
   104.98      43.16     73.67 0.                .24   .002  0.00  6.8783E-03   1.26   148.5      1.3745E-02   5.2508E+02   4.5202E-03
   109.37      44.22     73.68 0.                .24   .002  0.00  6.1487E-03   1.25   155.5      1.2640E-02   5.1142E+02   4.0486E-03
   113.77      45.29     73.69 0.                .25   .001  0.00  5.5008E-03   1.24   162.6      1.1635E-02   4.9803E+02   3.6292E-03
   118.17      46.38     73.69 0.                .25   .001  0.00  4.9271E-03   1.23   169.9      1.0726E-02   4.8490E+02   3.2575E-03
   122.57      47.48     73.70 0.                .25   .001  0.00  4.4199E-03   1.23   177.2      9.9053E-03   4.7205E+02   2.9285E-03
   126.97      48.59     73.70 0.                .26   .001  0.00  3.9719E-03   1.22   184.6      9.1650E-03   4.5949E+02   2.6375E-03
   131.36      49.72     73.71 0.                .26   .001  0.00  3.5761E-03   1.22   192.1      8.4976E-03   4.4721E+02   2.3801E-03
   135.76      50.87     73.71 0.                .26   .001  0.00  3.2260E-03   1.21   199.6      7.8956E-03   4.3522E+02   2.1522E-03
   140.16      52.03     73.71 0.                .27   .001  0.00  2.9161E-03   1.21   207.1      7.3521E-03   4.2352E+02   1.9501E-03
   144.56      53.21     73.71 0.                .27   .001  0.00  2.6412E-03   1.21   214.6      6.8607E-03   4.1211E+02   1.7708E-03
   148.96      54.41     73.72 0.                .27   .000  0.00  2.3969E-03   1.20   222.2      6.4158E-03   4.0098E+02   1.6112E-03
   153.35      55.62     73.72 0.                .28   .000  0.00  2.1795E-03   1.20   229.7      6.0123E-03   3.9012E+02   1.4690E-03
   157.75      56.84     73.72 0.                .28   .000  0.00  1.9856E-03   1.20   237.3      5.6455E-03   3.7955E+02   1.3420E-03
   162.15      58.08     73.72 0.                .28   .000  0.00  1.8122E-03   1.20   244.8      5.3115E-03   3.6925E+02   1.2283E-03
   166.55      59.33     73.72 0.                .29   .000  0.00  1.6569E-03   1.20   252.3      5.0067E-03   3.5921E+02   1.1264E-03
   170.95      60.59     73.72 0.                .29   .000  0.00  1.5174E-03   1.20   259.7      4.7280E-03   3.4944E+02   1.0347E-03
   175.35      61.87     73.72 0.                .29   .000  0.00  1.3920E-03   1.19   267.2      4.4726E-03   3.3992E+02   9.5219E-04
   179.74      63.15     73.72 0.                .29   .000  0.00  1.2789E-03   1.19   274.6      4.2382E-03   3.3066E+02   8.7768E-04
   184.14      64.45     73.73 0.                .30   .000  0.00  1.1768E-03   1.19   281.9      4.0225E-03   3.2163E+02   8.1028E-04
   188.54      65.76     73.73 0.                .30   .000  0.00  1.0843E-03   1.19   289.3      3.8236E-03   3.1285E+02   7.4921E-04
   192.94      67.08     73.73 0.                .30   .000  0.00  1.0005E-03   1.19   296.6      3.6400E-03   3.0431E+02   6.9374E-04
   197.34      68.41     73.73 0.                .30   .000  0.00  9.2428E-04   1.19   303.8      3.4701E-03   2.9599E+02   6.4329E-04
   201.73      69.74     73.73 0.                .31   .000  0.00  8.5495E-04   1.19   311.0      3.3126E-03   2.879CE+02   5.9730E-04
   206.13      71.09     73.73 0.                .31   .000  0.00  7.9174E-04   1.19   318.2      3.1664E-03   2.8002E+02   5.5531E-04
   210.53      72.44     73.73 0.                .31   .000  0.00  7.3401E-04   1.19   325.3      3.0304E-03   2.7236E+02   5.1691E-04
   214.93      73.81     73.73 0.                .31   .000  0.00  6.8120E-04   1.19   332.4      2.9037E-03   2.6490E+02   4.8174E-04
   219.33      75.18     73.73 0.                .31   .000  0.00  6.3282E-04   1.19   339.4      2.7854E-03   2.5765E+02   4.4946E-04
   223.72      76.56     73.73 0.                .31   .000  0.00  5.8843E-04   1.19   346.4      2.6749E-03   2.5059E+02   4.1981E-04
   228.12      77.94     73.73 0.                .32   .000  0.00  5.4765E-04   1.19   353.4      2.5715E-03   2.4372E+02   3.9252E-04
   232.52      79.33     73.73 0.                .32   .000  0.00  5.1012E-04   1.19   360.3      2.4745E-03   2.3704E+02   3.6737E-04
  245.71     83.55    73.73 0.        .32   .000  0.00  4.1418E-04   1.19  380.7    2.2176E-03  2.1807E+02  3.0287E-04
  250.11     84.96    73.73 0.        .32   .000  0.00  3.8694E-04   1.19  387.4    2.1417E-03  2.1209E+02  2.8449E-04
  254.51     86.39    73.73 0.        .32   .000  0.00  3.6171E-04   1.19  394.1    2.0702E-03  2.0627E+02  2.6744E-04
  258.91     87.81    73.73 0.        .33   .000  0.00  3.3834E-04   1.19  400.7    2.0026E-03  2.0061E+02  2.5162E-04
  263.31     89.25    73.73 0.        .33   .000  0.00  3.1665E-04   1.19  407.2    1.9388E-03  1.9511E+02  2.3691E-04
  267.71     90.68    73.73 0.        .33   .000  0.00  2.9650E-04   1.19  413.8    1.8783E-03  1.8975E+02  2.2322E-04
  272.10     92.13    73.73 0.        .33   .000  0.00  2.7777E-04   1.19  420.3    1.8210E-03  1.8454E+02  2.1047E-04
  276.50     93.57    73.73 0.        .33   .000  0.00  2.6034E-04   1.19  426.7    1.7667E-03  1.7948E+02  1.9859E-04
  280.90     95.02    73.73 0.        .33   .000  0.00  2.4411E-04   1.19  433.1    1.7151E-03  1.7455E+02  1.8750E-04
  285.30     96.48    73.73 0.        .33   .000  0.00  2.2898E-04   1.18  439.4    1.6661E-03  1.6976E+02  1.7714E-04
  289.70     97.94    73.73 0.        .33   .000  0.00  2.1486E-04   1.18  445.7    1.6194E-03  1.6510E+02  1.6745E-04
  294.09     99.40    73.73 0.        .33   .000  0.00  2.0168E-04   1.18  452.0    1.5750E-03  1.6057E+02  1.5839E-04
  298.49    100.87    73.73 0.        .33   .000  0.00  1.8936E-04   1.18  458.2    1.5327E-03  1.5616E+02  1.4990E-04
  302.89    102.34    73.73 0.        .33   .000  0.00  1.7784E-04   1.18  464.3    1.4923E-03  1.5187E+02  1.4195E-04
  307.29    103.82    73.73 0.        .34   .000  0.00  1.6706E-04   1.18  470.5    1.4538E-03  1.4770E+02  1.3449E-04
  311.69    105.29    73.73 0.        .34   .000  0.00  1.5697E-04   1.18  476.5    1.4170E-03  1.4364E+02  1.2748E-04
  316.08    106.78    73.73 0.        .34   .000  0.00  1.4750E-04   1.18  482.6    1.3819E-03  1.3970E+02  1.2090E-04
  320.48    108.26    73.73 0.        .34   .000  0.00  1.3863E-04   1.18  488.6    1.3482E-03  1.3586E+02  1.1472E-04
  324.88    109.75    73.73 0.        .34   .000  0.00  1.3030E-04   1.18  494.5    1.3160E-03  1.3213E+02  1.0890E-04
  329.28    111.24    73.73 0.        .34   .000  0.00  1.2249E-04   1.18  500.4    1.2852E-03  1.2850E+02  1.0343E-04
  333.68    112.73    73.73 0.        .34   .000  0.00  1.1514E-04   1.18  506.3    1.2556E-03  1.2497E+02  9.8273E-05
  338.07    114.23    73.73 0.        .34   .000  0.00  1.0824E-04   1.18  512.1    1.2272E-03  1.2154E+02  9.3414E-05
  342.47    115.73    73.73 0.        .34   .000  0.00  1.0174E-04   1.18  517.9    1.1999E-03  1.1820E+02  8.8831E-05
  346.87    117.23    73.73 0.        .34   .000  0.00  9.5635E-05   1.18  523.6    1.1738E-03  1.1495E+02  8.4507E-05
  351.27    118.74    73.73 0.        .34   .000  0.00  8.9883E-05   1.18  529.3    1.1486E-03  1.1180E+02  8.0425E-05
  355.67    120.24    73.73 0.        .34   .000  0.00  8.4465E-05   1.18  535.0    1.1244E-03  1.0873E+02  7.6569E-05
  360.07    121.75    73.73 0.        .34   .000  0.00  7.9359E-05   1.18  540.6    1.1012E-03  1.0574E+02  7.2925E-05
  364.46    123.27    73.73 0.        .34   .000  0.00  7.4545E-05   1.18  546.2    1.0788E-03  1.0284E+02  6.9479E-05
  368.86    124.78    73.73 0.        .34   .000  0.00  7.0004E-05   1.18  551.8    1.0572E-03  1.0001E+02  6.6218E-05
  373.26    126.30    73.73 0.        .35   .000  0.00  6.5720E-05   1.18  557.3    1.0364E-03  9.7263E+01  6.3132E-05
  377.66    127.82    73.73 0.        .35   .000  0.00  6.1675E-05   1.18  562.8    1.0163E-03  9.4592E+01  6.0209E-05
  382.06    129.34    73.73 0.        .35   .000  0.00  5.7856E-05   1.18  568.2    9.9696E-04  9.1993E+01  5.7441E-05
  386.45    130.86    73.73 0.        .35   .000  0.00  5.4248E-05   1.18  573.6    9.7828E-04  8.9466E+01  5.4816E-05
  390.85    132.39    73.73 0.        .35   .000  0.00  5.0838E-05   1.18  579.0    9.6024E-04  8.7009E+01  5.2327E-05
  395.25    133.91    73.73 0.        .35   .000  0.00  4.7615E-05   1.18  584.3    9.4280E-04  8.4619E+01  4.9966E-05
  399.65    135.44    73.73 0.        .35   .000  0.00  4.4567E-05   1.18  589.6    9.2595E-04  8.2295E+01  4.7725E-05
  404.05    136.97    73.73 0.        .35  -.000  0.00  4.1683E-05   1.18  594.8    9.0966E-04  8.0034E+01  4.5597E-05
  408.44    138.51    73.73 0.        .35  -.000  0.00  3.8954E-05   1.18  600.1    8.9389E-04  7.7836E+01  4.3576E-05
  412.84    140.04    73.73 0.        .35  -.000  0.00  3.6371E-05   1.18  605.2    8.7863E-04  7.5698E+01  4.1656E-05
  417.24    141.58    73.73 0.        .35  -.000  0.00  3.3926E-05   1.18  610.4    8.6386E-04  7.3618E+01  3.9830E-05
  421.64    143.12    73.73 0.        .35  -.000  0.00  3.1610E-05   1.18  615.5    8.4955E-04  7.1596E+01  3.8094E-05
  426.04    144.66    73.73 0.        .35  -.000  0.00  2.9416E-05   1.18  620.6    8.3567E-04  6.9630E+01  3.6443E-05
  430.43    146.20    73.73 0.        .35  -.000  0.00  2.7337E-05   1.18  625.7    8.2223E-04  6.7717E+01  3.4872E-05
  434.83    147.74    73.73 0.        .35  -.000  0.00  2.5367E-05   1.18  630.7    8.0919E-04  6.5857E+01  3.3376E-05
  439.23    149.29    73.73 0.        .35  -.000  0.00  2.3500E-05   1.18  635.7    7.9653E-04  6.4048E+01  3.1952E-05
  443.63    150.83    73.73 0.        .35  -.000  0.00  2.1729E-05   1.18  640.6    7.8425E-04  6.2289E+01  3.0595E-05
  448.03    152.38    73.73 0.        .35  -.000  0.00  2.0050E-05   1.18  645.5    7.7233E-04  6.0578E+01  2.9302E-05
  452.43    153.93    73.73 0.        .35  -.000  0.00  1.8457E-05   1.18  650.4    7.6075E-04  5.8914E+01  2.8070E-05
  456.82    155.48    73.73 0.        .35  -.000  0.00  1.6946E-05   1.18  655.3    7.4950E-04  5.7296E+01  2.6896E-05
  461.22    157.03    73.73 0.        .35  -.000  0.00  1.5512E-05   1.18  660.1    7.3857E-04  5.5722E+01  2.5775E-05
  465.62    158.58    73.73 0.        .35  -.000  0.00  1.4152E-05   1.18  664.9    7.2794E-04  5.4192E+01  2.4707E-05
  470.02    160.14    73.73 0.        .35  -.000  0.00  1.2861E-05   1.18  669.7    7.1761E-04  5.2703E+01  2.3687E-05
  474.42    161.69    73.73 0.        .35  -.000  0.00  1.1635E-05   1.18  674.4    7.0755E-04  5.1256E+01  2.2713E-05
  478.81    163.25    73.73 0.        .35  -.000  0.00  1.0471E-05   1.18  679.1    6.9776E-04  4.9848E+01  2.1784E-05
  483.21    164.81    73.73 0.        .35  -.000  0.00  9.3667E-06   1.18  683.8    6.8824E-04  4.8479E+01  2.0897E-05
  487.61    166.37    73.73 0.        .35  -.000  0.00  8.3178E-06   1.18  688.5    6.7897E-04  4.7147E+01  2.0049E-05
  492.01    167.93    73.73 0.        .35  -.000  0.00  7.3217E-06   1.18  693.1    6.6993E-04  4.5853E+01  1.9239E-05
  496.41    169.49    73.73 0.        .36  -.000  0.00  6.3757E-06   1.18  697.7    6.6113E-04  4.4593E+01  1.8465E-05
  500.80    171.05    73.73 0.        .36  -.000  0.00  5.4773E-06   1.18  702.2    6.5256E-04  4.3369E+01  1.7725E-05
  505.20    172.62    73.73 0.        .36  -.000  0.00  4.6241E-06   1.18  706.8    6.4420E-04  4.2178E+01  1.7017E-05
  509.60    174.18    73.73 0.        .36  -.000  0.00  3.8136E-06   1.18  711.3    6.3605E-04  4.1019E+01  1.6340E-05
  514.00    175.75    73.73 0.        .36  -.000  0.00  3.0438E-06   1.18  715.8    6.2810E-04  3.9893E+01  1.5693E-05
  518.40    177.31    73.73 0.        .36  -.000  0.00  2.3126E-06   1.18  720.2    6.2035E-04  3.8797E+01  1.5074E-05
  522.79    178.88    73.73 0.        .36  -.000  0.00  1.6181E-06   1.18  724.7    6.1278E-04  3.7732E+01  1.4481E-05
```

Section 4. Rhode Island Instantaneous Agglomeration Release

```
 AMBIENT CONDITIONS
DEPTH IN FT.  DENSITY IN GRAM PER CC.  KY IN SQFT PER SEC.  VEL. IN FPS.
DEPTH             0.         1.0000E+02
AMB-DENSITY      1.0200E+00  1.0250E+00

YK               1.0000E+02  1.0000E+02  1.0000E+02  1.0000E+02
KY               5.0000E-02  5.0000E-02  5.0000E-02

YU 5.0000E+01YW 5.0000E+01YE 1.5000E+02H 1.0000E+02
UA 1.0000E+00WA 0.


BARGE OPERATION 1

WASTE MATERIAL DUMPED INSTANTANEOUSLY INTO THE OCEAN

THE SHAPE OF THE CLOUD IS ASSUMED TO BE HEMISPHERE

TSTOP  1.8000E+03SEC.

GRID POINT SIZE   51 KEY1    2 KEY2    2 KEY3    0

USE READ IN COEFFICIENTS

DINCR1     1.0000 DINCR2     1.0000
ALPHA0      .0100 BETA    1.0000 CM     1.0000 CD      .5000
GAMA  .25 CDRAG 1.00 CFRIC .010 CD3  .10 CD4 1.00 ALPHAC      .0010
FRICIN      .0100 FI        .1000
ALFA1    1.0000 ALFA2     1.0000 GAMA1     0.0000 GAMA2     0.0000
ALAMDA      .0010

RB  2.0500E+01 ROO  1.7000E+00 U  3.0000E+00 V  0.          W  5.0000E-01
       K    1  L    1
DENSITY OF SOLID            2.6000E+00
CONCENTRATION
                            4.4000E-01
FALL VELOCITY OF SOLID
                            1.0000E-03
```

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```
CONVECTIVE DESCENT

 1  5.0000E+00    1    0    2

 2  6.6667E-02    1    0   70

 3  3.1111E-02    1    0  147

 TIME     X       Y        Z     U      V      W      DEN-DIF    RADIUS VORT.  ALPHA  FLUID CONC. SOLID-VOL.  CONCENTRATION
 0.00    0.00    0.00     0.00  3.00  0.000   .50  6.7998E-01   20.50   0.00  .0100  5.6000E-01  7.9391E+03  4.4000E-01
  .06     .19     .02      .03  3.00   .801   .50  6.7985E-01   20.50   0.00  .0100  5.5989E-01  7.9391E+03  4.3992E-01
  .12     .37     .10      .06  3.00  1.600   .50  6.7970E-01   20.50   0.00  .0100  5.5977E-01  7.9391E+03  4.3982E-01
  .19     .56     .22      .09  2.99  2.397   .50  6.7951E-01   20.50   0.00  .0100  5.5962E-01  7.9391E+03  4.3970E-01
  .25     .75     .40      .12  2.99  3.191   .50  6.7929E-01   20.51   0.00  .0100  5.5945E-01  7.9391E+03  4.3957E-01
  .31     .93     .62      .16  2.99  3.980   .50  6.7902E-01   20.51   0.00  .0100  5.5924E-01  7.9391E+03  4.3940E-01
  .37    1.12     .89      .19  2.98  4.765   .50  6.7871E-01   20.51   0.00  .0100  5.5899E-01  7.9391E+03  4.3921E-01
  .44    1.30    1.21      .22  2.98  5.545   .50  6.7835E-01   20.52   0.00  .0100  5.5871E-01  7.9391E+03  4.3899E-01
  .50    1.49    1.58      .25  2.98  6.317   .49  6.7795E-01   20.52   0.00  .0100  5.5839E-01  7.9391E+03  4.3874E-01
  .56    1.67    2.00      .28  2.97  7.082   .49  6.7750E-01   20.52   0.00  .0100  5.5803E-01  7.9391E+03  4.3846E-01
  .62    1.86    2.46      .31  2.96  7.839   .49  6.7700E-01   20.53   0.00  .0100  5.5764E-01  7.9391E+03  4.3815E-01
  .68    2.04    2.98      .34  2.96  8.587   .49  6.7645E-01   20.53   0.00  .0100  5.5721E-01  7.9391E+03  4.3781E-01
  .75    2.23    3.53      .37  2.95  9.325   .49  6.7586E-01   20.54   0.00  .0100  5.5675E-01  7.9391E+03  4.3745E-01
  .81    2.41    4.14      .40  2.94 10.052   .49  6.7522E-01   20.55   0.00  .0100  5.5625E-01  7.9391E+03  4.3705E-01
  .87    2.59    4.78      .43  2.93 10.769   .48  6.7454E-01   20.55   0.00  .0100  5.5571E-01  7.9391E+03  4.3663E-01
  .93    2.77    5.48      .46  2.93 11.473   .48  6.7381E-01   20.56   0.00  .0100  5.5514E-01  7.9391E+03  4.3618E-01
 1.00    2.96    6.21      .49  2.92 12.165   .48  6.7304E-01   20.57   0.00  .0100  5.5454E-01  7.9391E+03  4.3571E-01
 1.06    3.14    6.99      .52  2.91 12.844   .48  6.7223E-01   20.57   0.00  .0100  5.5390E-01  7.9391E+03  4.3521E-01
 1.12    3.32    7.81      .55  2.90 13.510   .47  6.7138E-01   20.58   0.00  .0100  5.5323E-01  7.9391E+03  4.3468E-01
 1.18    3.50    8.67      .58  2.89 14.162   .47  6.7048E-01   20.59   0.00  .0100  5.5253E-01  7.9391E+03  4.3413E-01
 1.24    3.68    9.57      .61  2.88 14.800   .47  6.6955E-01   20.60   0.00  .0100  5.5180E-01  7.9391E+03  4.3356E-01
 1.31    3.86   10.51      .64  2.86 15.423   .47  6.6858E-01   20.61   0.00  .0100  5.5104E-01  7.9391E+03  4.3296E-01
 1.37    4.03   11.49      .67  2.85 16.032   .46  6.6757E-01   20.62   0.00  .0100  5.5025E-01  7.9391E+03  4.3234E-01
 1.43    4.21   12.51      .69  2.84 16.625   .46  6.6653E-01   20.63   0.00  .0100  5.4943E-01  7.9391E+03  4.3170E-01
 1.49    4.39   13.56      .72  2.83 17.204   .46  6.6545E-01   20.64   0.00  .0100  5.4859E-01  7.9391E+03  4.3103E-01
 1.56    4.56   14.65      .75  2.82 17.767   .45  6.6434E-01   20.65   0.00  .0100  5.4772E-01  7.9391E+03  4.3035E-01
 1.62    4.74   15.77      .78  2.80 18.314   .45  6.6320E-01   20.66   0.00  .0100  5.4682E-01  7.9391E+03  4.2964E-01
 1.68    4.91   16.93      .81  2.79 18.846   .45  6.6202E-01   20.67   0.00  .0100  5.4590E-01  7.9391E+03  4.2892E-01
 1.74    5.08   18.11      .84  2.78 19.363   .44  6.6082E-01   20.69   0.00  .0100  5.4495E-01  7.9391E+03  4.2818E-01
 1.80    5.26   19.33      .86  2.76 19.864   .44  6.5958E-01   20.70   0.00  .0100  5.4399E-01  7.9391E+03  4.2742E-01
 1.87    5.43   20.59      .89  2.75 20.349   .44  6.5832E-01   20.71   0.00  .0100  5.4300E-01  7.9391E+03  4.2664E-01
 1.93    5.60   21.87      .92  2.73 20.820   .43  6.5703E-01   20.72   0.00  .0100  5.4199E-01  7.9391E+03  4.2585E-01
 1.99    5.77   23.18      .94  2.72 21.275   .43  6.5572E-01   20.74   0.00  .0100  5.4096E-01  7.9391E+03  4.2504E-01
 2.05    5.94   24.51      .97  2.70 21.715   .43  6.5438E-01   20.75   0.00  .0100  5.3991E-01  7.9391E+03  4.2421E-01
 2.12    6.10   25.88     1.00  2.69 22.139   .42  6.5302E-01   20.76   0.00  .0100  5.3884E-01  7.9391E+03  4.2337E-01
 2.18    6.27   27.27     1.02  2.67 22.550   .42  6.5164E-01   20.78   0.00  .0100  5.3776E-01  7.9391E+03  4.2252E-01
 2.24    6.44   28.68     1.05  2.66 22.945   .41  6.5023E-01   20.79   0.00  .0100  5.3666E-01  7.9391E+03  4.2166E-01
 2.30    6.60   30.12     1.08  2.64 23.326   .41  6.4881E-01   20.81   0.00  .0100  5.3554E-01  7.9391E+03  4.2078E-01
 2.36    6.77   31.59     1.10  2.63 23.694   .41  6.4736E-01   20.82   0.00  .0100  5.3441E-01  7.9391E+03  4.1989E-01
 2.43    6.93   33.07     1.13  2.61 24.047   .40  6.4590E-01   20.84   0.00  .0100  5.3326E-01  7.9391E+03  4.1899E-01
 2.49    7.09   34.58     1.15  2.60 24.387   .40  6.4443E-01   20.85   0.00  .0100  5.3211E-01  7.9391E+03  4.1808E-01
 2.55    7.25   36.11     1.18  2.58 24.714   .40  6.4293E-01   20.87   0.00  .0100  5.3094E-01  7.9391E+03  4.1716E-01
 2.61    7.41   37.65     1.20  2.57 25.027   .39  6.4142E-01   20.88   0.00  .0100  5.2975E-01  7.9391E+03  4.1624E-01
 2.68    7.57   39.22     1.22  2.55 25.328   .39  6.3990E-01   20.90   0.00  .0100  5.2856E-01  7.9391E+03  4.1530E-01
 2.74    7.73   40.81     1.25  2.53 25.617   .38  6.3836E-01   20.91   0.00  .0100  5.2736E-01  7.9391E+03  4.1435E-01
 2.80    7.89   42.41     1.27  2.52 25.894   .38  6.3682E-01   20.93   0.00  .0100  5.2615E-01  7.9391E+03  4.1340E-01
 2.86    8.04   44.03     1.30  2.50 26.159   .38  6.3526E-01   20.95   0.00  .0100  5.2492E-01  7.9391E+03  4.1244E-01
 2.92    8.20   45.66     1.32  2.49 26.413   .37  6.3369E-01   20.96   0.00  .0100  5.2369E-01  7.9391E+03  4.1147E-01
 2.99    8.35   47.31     1.34  2.47 26.655   .37  6.3211E-01   20.98   0.00  .0100  5.2246E-01  7.9391E+03  4.1050E-01
 3.05    8.51   48.94     1.36  2.46 26.887   .36  6.3052E-01   21.00   0.00  .0100  5.2121E-01  7.9391E+03  4.0952E-01
 3.11    8.66   50.60     1.39  2.44 27.109   .36  6.2892E-01   21.01   0.00  .0100  5.1996E-01  7.9391E+03  4.0854E-01
```

```
     COLLAPSE PHASE
 1  3.1111E-02    1     0   599
 2  5.6244E-02    1     0   599
 3  1.0170E-01    1     0   599
 4  1.8387E-01    1     0   599
 5  3.3244E-01    4     3   189
TIME          X          Y         Z        U       V      W     DEN-DIF      A        B        FLUID CONC.   SOLID-VOL.   CONCENTRATION
     4.54      11.88     91.97    1.841          2.05  30.025   .28  5.9119E-01  10.71   21.43     4.9043E-01  7.9391E+03  3.8533E-01
     4.87      12.56     96.62    1.932          2.04   6.169   .27  5.8599E-01   4.71   32.47     4.8630E-01  7.9391E+03  3.8209E-01
     5.21      13.19     97.44    2.017          1.76   2.529   .24  5.8307E-01   2.96   41.04     4.8393E-01  7.9391E+03  3.8023E-01
     5.54      13.70     98.56    2.093          1.68   1.357   .23  5.8041E-01   2.14   48.34     4.8175E-01  7.9391E+03  3.7852E-01
     5.87      14.31     98.91    2.167          1.63    .840   .22  5.7766E-01   1.67   54.85     4.7949E-01  7.9391E+03  3.7674E-01
     6.20      14.85     99.14    2.238          1.58    .569   .21  5.7470E-01   1.37   60.79     4.7704E-01  7.9391E+03  3.7482E-01
     6.54      15.36     99.30    2.307          1.54    .409   .21  5.7149E-01   1.16   66.29     4.7438E-01  7.9391E+03  3.7273E-01
     6.87      15.87     99.42    2.374          1.49    .308   .20  5.6804E-01   1.00   71.45     4.7152E-01  7.9391E+03  3.7048E-01
     7.20      16.36     99.51    2.440          1.45    .240   .19  5.6435E-01    .88   76.34     4.6846E-01  7.9391E+03  3.6808E-01
     7.53      16.83     99.58    2.503          1.41    .192   .19  5.6046E-01    .79   80.98     4.6523E-01  7.9391E+03  3.6554E-01
     7.87      17.29     99.64    2.564          1.37    .157   .18  5.5638E-01    .72   85.42     4.6185E-01  7.9391E+03  3.6289E-01
     8.20      17.74     99.69    2.623          1.32    .130   .18  5.5216E-01    .65   89.69     4.5835E-01  7.9391E+03  3.6013E-01
     8.53      18.17     99.73    2.680          1.28    .110   .17  5.4781E-01    .60   93.79     4.5474E-01  7.9391E+03  3.5729E-01
     8.86      18.59     99.76    2.736          1.24    .094   .16  5.4336E-01    .56   97.75     4.5105E-01  7.9391E+03  3.5439E-01
     9.20      19.00     99.79    2.789          1.20    .081   .16  5.3884E-01    .52   101.6     4.4730E-01  7.9391E+03  3.5145E-01
     9.53      19.39     99.82    2.841          1.16    .070   .15  5.3427E-01    .49   105.3     4.4351E-01  7.9391E+03  3.4847E-01
     9.86      19.77     99.84    2.890          1.12    .062   .15  5.2969E-01    .46   108.9     4.3970E-01  7.9391E+03  3.4548E-01
    10.19      20.13     99.86    2.938          1.08    .055   .14  5.2510E-01    .44   112.3     4.3590E-01  7.9391E+03  3.4249E-01
    10.53      20.49     99.87    2.984          1.04    .049   .14  5.2054E-01    .42   115.7     4.3211E-01  7.9391E+03  3.3952E-01
    10.86      20.83     99.89    3.028          1.00    .044   .13  5.1602E-01    .40   119.0     4.2836E-01  7.9391E+03  3.3657E-01
    11.19      21.15     99.90    3.071           .96    .039   .12  5.1156E-01    .38   122.2     4.2466E-01  7.9391E+03  3.3366E-01
    11.52      21.47     99.91    3.111           .93    .035   .12  5.0718E-01    .37   125.3     4.2102E-01  7.9391E+03  3.3080E-01
    11.86      21.77     99.93    3.150           .89    .032   .11  5.0290E-01    .35   128.3     4.1746E-01  7.9391E+03  3.2801E-01
    12.19      22.06     99.94    3.187           .85    .029   .11  4.9871E-01    .34   131.2     4.1399E-01  7.9391E+03  3.2528E-01
    12.52      22.33     99.95    3.223           .81    .027   .10  4.9465E-01    .33   134.0     4.1062E-01  7.9391E+03  3.2263E-01
    12.85      22.60     99.95    3.256           .78    .024   .10  4.9072E-01    .32   136.8     4.0736E-01  7.9391E+03  3.2007E-01
    13.19      22.85     99.96    3.289           .74    .022   .09  4.8693E-01    .31   139.4     4.0421E-01  7.9391E+03  3.1760E-01
    13.52      23.09     99.97    3.319           .71    .021   .09  4.8329E-01    .30   142.0     4.0119E-01  7.9391E+03  3.1522E-01
    13.85      23.32     99.98    3.348           .67    .019   .08  4.7981E-01    .29   144.5     3.9830E-01  7.9391E+03  3.1295E-01
    14.18      23.54     99.98    3.376           .64    .018   .08  4.7649E-01    .28   146.9     3.9554E-01  7.9391E+03  3.1078E-01
    14.52      23.75     99.99    3.401           .60    .016   .08  4.7333E-01    .28   149.2     3.9292E-01  7.9391E+03  3.0872E-01
    14.85      23.94     99.99    3.426           .57    .015   .07  4.7033E-01    .27   151.5     3.9044E-01  7.9391E+03  3.0677E-01
    15.18      24.13    100.00    3.449           .54    .014   .07  4.6750E-01    .26   153.6     3.8808E-01  7.9391E+03  3.0492E-01
    15.51      24.30    100.00    3.470           .50    .011   .06 -2.4259E+01    .25   157.0     3.8583E-01  7.9391E+03  3.0316E-01
    15.85      24.47     99.96    3.490           .50   -.259   .06 -2.4228E+01    .25   159.4     3.8534E-01  7.9391E+03  3.0277E-01
    16.18      24.63     99.85    3.509           .50   -.492   .06 -2.4205E+01    .24   161.2     3.8497E-01  7.9391E+03  3.0247E-01
    16.51      24.80     99.66    3.528           .50   -.708   .06 -2.4187E+01    .24   162.7     3.8468E-01  7.9391E+03  3.0225E-01
    16.84      24.97     99.41    3.546           .50   -.911   .06 -2.4173E+01    .23   163.8     3.8446E-01  7.9391E+03  3.0208E-01
    17.17      25.14     99.10    3.565           .50  -1.104   .06 -2.4162E+01    .23   164.8     3.8429E-01  7.9391E+03  3.0195E-01
    17.51      25.30     98.73    3.583           .50  -1.288   .06 -2.4154E+01    .23   165.6     3.8417E-01  7.9391E+03  3.0185E-01
    17.84      25.47     98.31    3.602           .50  -1.465   .06 -2.4150E+01    .23   166.3     3.8409E-01  7.9391E+03  3.0179E-01
    18.17      25.64     97.84    3.620           .50  -1.645   .06 -2.4152E+01    .23   166.8     3.8414E-01  7.9391E+03  3.0182E-01
    18.50      25.81     97.33    3.638           .50  -1.870   .06 -2.4183E+01    .23   166.7     3.8463E-01  7.9391E+03  3.0221E-01
***THE STEP INCREMENT BEFORE LONG TERM DIFFUSION IN TROUBLE*** $$  5.5849E-02
```

Section 5. Slurry Jet with Clumps

```
 AMBIENT CONDITIONS
 DEPTH IN FT.  DENSITY IN GRAM PER CC.  KY IN SQFT PER SEC.  VEL. IN FPS.
 DEPTH              0.           8.0000E+01
 AMB-DENSITY        1.0200E+00   1.0220E+00

 YK                    8.0000E+01  8.0000E+01  8.0000E+01  8.0000E+01
 KY                    5.0000E-03  5.0000E-03  5.0000E-03

 YU 1.0000E+01YW 1.0000E+01YE 8.0000E+01H 7.0000E+01
 UA 1.0000E+00WA 0.


 BARGE OPERATION 2
 DISCHARGE THROUGH A NOZZLE UNDER A MOVING BARGE

 TSTOP  3.0000E+03SEC.

 GRID POINT SIZE   51 KEY1    1 KEY2    3 KEY3    1

 USE TETRA TECH SUGGESTED COEFFICIENTS

 DINCR1    1.0000 DINCR2    1.0000
 ALPHA1     .0806  ALPHA2      .3536  BETA    0.0000 CD     1.3000
 GAMA  .25 CDRAG 1.00 CFRIC .010 CD3  .20 CD4 2.00 ALPHA3      .3536
 ALPHA4     .0010 FRICTN      .0100 F1      .1000 CM    1.0000
 ALFA1    1.0000 ALFA2     1.0000 GAMA1    0.0000 GAMA2    0.0000
 ALAMDA     .0010

 JET RADIUS       5.6000  DENSITY    1.4800  ANGLE OF JET    0.0000
 VELOCITY     .0500 AT   13.0000 FT.
          K   3 L   2
 DENSITY OF SOLID             2.6500E+00
 CONCENTRATION                1.5000E-02  1.5000E-02
 FALL VELOCITY OF SOLID       5.0000E-02  5.0000E-03
 DENSITY OF SOLID             1.7000E+00
 CONCENTRATION                1.1400E-01  1.1400E-01
 FALL VELOCITY OF SOLID       1.0000E-01  3.0000E-01
 DENSITY OF SOLID             1.7000E+00
 CONCENTRATION                1.1400E-01  1.1400E-01
 FALL VELOCITY OF SOLID       6.0000E-01  9.0000E-01
 BARGE VELOCITY    3.5000 ANGLE WITH X-AXIS  180.0000 DEGREES FOR4.5000E+02 SEC.

 AMBIENT CURRENT FOR A MOVING COORDINATE FIXED ON THE BARGE
      0        YU       YW        YE       H
   4.5000  4.5000             3.5000  3.5000
  -0.0000           0.0000 -0.0000 -0.0000
```

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JET CONVECTION

1 1.0000E+00  5.6000E+00   1   0   16

2 1.1429E-01  5.6000E+00   1   0   41

3 3.3469E-02  5.6000E+00   1   0   86

4 2.0560E-02  5.6000E+00   1   0  126
      T        S        X        Y          Z         U   RADIUS    DEN-DIF   FLUID CONC.FLUX OF SOLID  CONCENTRATION
     0.00     0.00     0.00    13.00      0.00      .050   5.600  4.5966E-01  5.1400E-01  7.3890E-02  1.5000E-02
                                                                                         7.3890E-02  1.5000E-02
                                                                                         5.6157E-01  1.1400E-01
                                                                                         5.6157E-01  1.1400E-01
                                                                                         5.6157E-01  1.1400E-01
                                                                                         5.6157E-01  1.1400E-01
     2.56      .27      .06    13.22      0.00     5.743    .556  4.0107E-01  4.5417E-01  7.3890E-02  1.3254E-02
                                                                                         7.3890E-02  1.3254E-02
                                                                                         5.5937E-01  1.0034E-01
                                                                                         5.5498E-01  9.9549E-02
                                                                                         5.4839E-01  9.8367E-02
                                                                                         5.4180E-01  9.7185E-02
     2.61      .59      .14    13.50      0.00     5.717    .596  3.5028E-01  3.9667E-01  7.3890E-02  1.1576E-02
                                                                                         7.3890E-02  1.1576E-02
                                                                                         5.5937E-01  8.7633E-02
                                                                                         5.5498E-01  8.6944E-02
                                                                                         5.4839E-01  8.5912E-02
                                                                                         5.4180E-01  8.4880E-02
     2.68      .98      .28    13.83      0.00     5.632    .656  2.9337E-01  3.3223E-01  7.3890E-02  9.6955E-03
                                                                                         7.3890E-02  9.6955E-03
                                                                                         5.5937E-01  7.3398E-02
                                                                                         5.5498E-01  7.2821E-02
                                                                                         5.4839E-01  7.1957E-02
                                                                                         5.4180E-01  7.1092E-02
     2.77     1.45      .51    14.19      0.00     5.521    .738  2.3699E-01  2.6839E-01  7.3890E-02  7.8323E-03
                                                                                         7.3890E-02  7.8323E-03
                                                                                         5.5937E-01  5.9293E-02
                                                                                         5.5498E-01  5.8827E-02
                                                                                         5.4839E-01  5.8129E-02
                                                                                         5.4180E-01  5.7431E-02
     2.87     2.02      .85    14.58      0.00     5.414    .838  1.8711E-01  2.1191E-01  7.3890E-02  6.1841E-03
                                                                                         7.3890E-02  6.1841E-03
                                                                                         5.5937E-01  4.6815E-02
                                                                                         5.5498E-01  4.6448E-02
                                                                                         5.4839E-01  4.5896E-02
                                                                                         5.4180E-01  4.5345E-02
     3.00     2.71     1.32    14.99      0.00     5.328    .955  1.4638E-01  1.6579E-01  7.3890E-02  4.8383E-03
                                                                                         7.3890E-02  4.8383E-03
                                                                                         5.5937E-01  3.6627E-02
                                                                                         5.5498E-01  3.6340E-02
                                                                                         5.4839E-01  3.5908E-02
                                                                                         5.4180E-01  3.5477E-02
     3.15     3.54     1.94    15.43      0.00     5.260   1.087  1.1444E-01  1.2963E-01  7.3890E-02  3.7829E-03
                                                                                         7.3890E-02  3.7829E-03
                                                                                         5.5937E-01  2.8638E-02
                                                                                         5.5498E-01  2.8413E-02
                                                                                         5.4839E-01  2.8076E-02
                                                                                         5.4180E-01  2.7798E-02
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3.35	4.55	2.72	15.90	0.00	5.203	1.235	8.9677E-02	1.0159E-01	7.3890E-02	2.9647E-03
									7.3890E-02	2.9647E-03
									5.5937E-01	2.2444E-02
									5.5498E-01	2.2267E-02
									5.4839E-01	2.2003E-02
									5.4180E-01	2.1739E-02
3.58	5.78	3.71	16.42	0.00	5.150	1.400	7.0427E-02	7.9796E-02	7.3890E-02	2.3287E-03
									7.3890E-02	2.3287E-03
									5.5937E-01	1.7629E-02
									5.5498E-01	1.7490E-02
									5.4839E-01	1.7283E-02
									5.4180E-01	1.7075E-02
3.87	7.25	4.93	16.98	0.00	5.099	1.587	5.5361E-02	6.2740E-02	7.3890E-02	1.8309E-03
									7.3890E-02	1.8309E-03
									5.5937E-01	1.3861E-02
									5.5498E-01	1.3752E-02
									5.4839E-01	1.3589E-02
									5.4180E-01	1.3425E-02
4.22	9.04	6.43	17.61	0.00	5.047	1.799	4.3499E-02	4.9313E-02	7.3890E-02	1.4391E-03
									7.3890E-02	1.4391E-03
									5.5937E-01	1.0894E-02
									5.5498E-01	1.0809E-02
									5.4839E-01	1.0681E-02
									5.4180E-01	1.0552E-02
4.65	11.21	8.27	18.31	0.00	4.996	2.042	3.4128E-02	3.8707E-02	7.3890E-02	1.1296E-03
									7.3890E-02	1.1296E-03
									5.5937E-01	8.5512E-03
									5.5498E-01	8.4841E-03
									5.4839E-01	8.3834E-03
									5.4180E-01	8.2826E-03
5.18	13.83	10.51	19.11	0.00	4.943	2.319	2.6716E-02	3.0321E-02	7.3890E-02	8.8484E-04
									7.3890E-02	8.8484E-04
									5.5937E-01	6.6985E-03
									5.5498E-01	6.6459E-03
									5.4839E-01	6.5670E-03
									5.4180E-01	6.4881E-03
5.82	17.00	13.25	20.01	0.00	4.890	2.637	2.0859E-02	2.3696E-02	7.3890E-02	6.9152E-04
									7.3890E-02	6.9152E-04
									5.5937E-01	5.2350E-03
									5.5498E-01	5.1939E-03
									5.4839E-01	5.1322E-03
									5.4180E-01	5.0706E-03
6.61	20.83	16.58	21.03	0.00	4.838	3.003	1.6240E-02	1.8475E-02	7.3890E-02	5.3916E-04
									7.3890E-02	5.3916E-04
									5.5937E-01	4.0816E-03
									5.5498E-01	4.0495E-03
									5.4839E-01	4.0014E-03
									5.4180E-01	3.9534E-03
7.54	25.35	20.64	22.20	0.00	4.786	3.423	1.2608E-02	1.4372E-02	7.3890E-02	4.1942E-04
									7.3890E-02	4.1942E-04
									5.5937E-01	3.1751E-03
									5.5498E-01	3.1502E-03
									5.4839E-01	3.1128E-03
									5.4180E-01	3.0754E-03
8.51	29.95	25.08	23.40	0.00	4.739	3.860	9.9873E-03	1.1416E-02	7.3890E-02	3.3314E-04
									7.3890E-02	3.3314E-04
									5.5937E-01	2.5220E-03
									5.5498E-01	2.5022E-03
									5.4839E-01	2.4725E-03
									5.4180E-01	2.4428E-03
9.48	34.56	29.54	24.55	0.00	4.699	4.278	8.1727E-03	9.3713E-03	7.3890E-02	2.7348E-04
									7.3890E-02	2.7348E-04
									5.5937E-01	2.0703E-03
									5.5498E-01	2.0541E-03
									5.4839E-01	2.0297E-03

```
10.46    39.16    34.02    25.65     0.00   4.665   4.681  6.8518E-03  7.8856E-03  7.3890E-02  2.3012E-04
                                                                                    7.3890E-02  2.3012E-04
                                                                                    5.5937E-01  1.7421E-03
                                                                                    5.5498E-01  1.7284E-03
                                                                                    5.4839E-01  1.7079E-03
                                                                                    5.4180E-01  1.6874E-03
11.45    43.77    38.50    26.70     0.00   4.634   5.070  5.8529E-03  6.7642E-03  7.3890E-02  1.9740E-04
                                                                                    7.3890E-02  1.9740E-04
                                                                                    5.5937E-01  1.4944E-03
                                                                                    5.5498E-01  1.4826E-03
                                                                                    5.4839E-01  1.4650E-03
                                                                                    5.4180E-01  1.4474E-03
12.45    48.37    42.99    27.73     0.00   4.607   5.449  5.0746E-03  5.8923E-03  7.3890E-02  1.7196E-04
                                                                                    7.3890E-02  1.7196E-04
                                                                                    5.5937E-01  1.3017E-03
                                                                                    5.5498E-01  1.2915E-03
                                                                                    5.4839E-01  1.2762E-03
                                                                                    5.4180E-01  1.2609E-03
13.45    52.98    47.48    28.72     0.00   4.583   5.817  4.4532E-03  5.1979E-03  7.3890E-02  1.5169E-04
                                                                                    7.3890E-02  1.5169E-04
                                                                                    5.5937E-01  1.1483E-03
                                                                                    5.5498E-01  1.1393E-03
                                                                                    5.4839E-01  1.1258E-03
                                                                                    5.4180E-01  1.1123E-03
14.46    57.58    51.99    29.69     0.00   4.560   6.176  3.9471E-03  4.6339E-03  7.3890E-02  1.3523E-04
                                                                                    7.3890E-02  1.3523E-04
                                                                                    5.5937E-01  1.0237E-03
                                                                                    5.5498E-01  1.0157E-03
                                                                                    5.4839E-01  1.0036E-03
                                                                                    5.4180E-01  9.9157E-04
15.47    62.19    56.50    30.63     0.00   4.540   6.527  3.5279E-03  4.1680E-03  7.3890E-02  1.2163E-04
                                                                                    7.3890E-02  1.2163E-04
                                                                                    5.5937E-01  9.2080E-04
                                                                                    5.5498E-01  9.1356E-04
                                                                                    5.4839E-01  9.0272E-04
                                                                                    5.4180E-01  8.9187E-04
16.48    66.79    61.01    31.55     0.00   4.520   6.870  3.1569E-03  3.7778E-03  7.3890E-02  1.1025E-04
                                                                                    7.3890E-02  1.1025E-04
                                                                                    5.5937E-01  8.3460E-04
                                                                                    5.5498E-01  8.2804E-04
                                                                                    5.4839E-01  8.1821E-04
                                                                                    5.2314E-01  7.8054E-04
17.50    71.40    65.53    32.44     0.00   4.502   7.207  2.8213E-03  3.4472E-03  7.3890E-02  1.0060E-04
                                                                                    7.3890E-02  1.0060E-04
                                                                                    5.5937E-01  7.6156E-04
                                                                                    5.5498E-01  7.5558E-04
                                                                                    5.4839E-01  7.4661E-04
                                                                                    4.8218E-01  6.5648E-04
18.53    76.00    70.05    33.32     0.00   4.484   7.537  2.5379E-03  3.1642E-03  7.3890E-02  9.2341E-05
                                                                                    7.3890E-02  9.2341E-05
                                                                                    5.5937E-01  6.9905E-04
                                                                                    5.5498E-01  6.9356E-04
                                                                                    5.4839E-01  6.8533E-04
                                                                                    4.4591E-01  5.5725E-04
19.55    80.61    74.57    34.18     0.00   4.468   7.860  2.2959E-03  2.9198E-03  7.3890E-02  8.5210E-05
                                                                                    7.3890E-02  8.5210E-05
                                                                                    5.5937E-01  6.4506E-04
                                                                                    5.5498E-01  6.3999E-04
                                                                                    5.4839E-01  6.3240E-04
                                                                                    4.1359E-01  4.7695E-04
20.59    85.22    79.10    35.02     0.00   4.452   8.178  2.0874E-03  2.7071E-03  7.3890E-02  7.9000E-05
                                                                                    7.3890E-02  7.9000E-05
                                                                                    5.5937E-01  5.9806E-04
                                                                                    5.5498E-01  5.9336E-04
                                                                                    5.4839E-01  5.8631E-04
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21.62    89.82    83.63    35.84    0.00   4.437    8.489  1.9060E-03  2.5205E-03  7.3890E-02  7.3555E-05
                                                                                  7.3890E-02  7.3555E-05
                                                                                  5.5937E-01  5.5683E-04
                                                                                  5.5498E-01  5.5246E-04
                                                                                  5.4839E-01  5.4590E-04
                                                                                  3.5860E-01  3.5698E-04
22.66    94.43    88.17    36.65    0.00   4.422    8.796  1.7471E-03  2.3557E-03  7.3890E-02  6.8746E-05
                                                                                  7.3890E-02  6.8746E-05
                                                                                  5.5937E-01  5.2043E-04
                                                                                  5.5498E-01  5.1634E-04
                                                                                  5.4839E-01  5.1021E-04
                                                                                  3.3508E-01  3.1175E-04
23.70    99.03    92.70    37.44    0.00   4.409    9.096  1.6067E-03  2.2093E-03  7.3890E-02  6.4475E-05
                                                                                  7.3890E-02  6.4475E-05
                                                                                  5.5937E-01  4.8809E-04
                                                                                  5.5498E-01  4.8426E-04
                                                                                  5.4839E-01  4.7851E-04
                                                                                  3.1373E-01  2.7376E-04
24.75   103.64    97.24    38.22    0.00   4.395    9.392  1.4820E-03  2.0786E-03  7.3890E-02  6.0659E-05
                                                                                  7.3890E-02  6.0659E-05
                                                                                  5.5937E-01  4.5921E-04
                                                                                  5.5498E-01  4.5560E-04
                                                                                  5.4839E-01  4.5019E-04
                                                                                  2.9431E-01  2.4161E-04
25.80   108.24   101.78    38.98    0.00   4.383    9.683  1.3705E-03  1.9612E-03  7.3890E-02  5.7234E-05
                                                                                  7.3890E-02  5.7234E-05
                                                                                  5.5937E-01  4.3328E-04
                                                                                  5.5498E-01  4.2987E-04
                                                                                  5.4839E-01  4.2477E-04
                                                                                  2.7657E-01  2.1422E-04
26.85   112.85   106.33    39.72    0.00   4.370    9.970  1.2703E-03  1.8553E-03  7.3890E-02  5.4144E-05
                                                                                  7.3890E-02  5.4144E-05
                                                                                  5.5937E-01  4.0988E-04
                                                                                  5.5498E-01  4.0666E-04
                                                                                  5.4839E-01  4.0184E-04
                                                                                  2.6032E-01  1.9075E-04
27.90   117.45   110.87    40.46    0.00   4.358   10.252  1.1797E-03  1.7594E-03  7.3890E-02  5.1345E-05
                                                                                  7.3890E-02  5.1345E-05
                                                                                  5.5937E-01  3.8869E-04
                                                                                  5.5498E-01  3.8564E-04
                                                                                  5.4839E-01  3.8106E-04
                                                                                  2.4540E-01  1.7052E-04
28.96   122.06   115.42    41.18    0.00   4.347   10.530  1.0974E-03  1.6722E-03  7.3890E-02  4.8799E-05
                                                                                  7.3890E-02  4.8799E-05
                                                                                  5.5937E-01  3.6942E-04
                                                                                  5.5498E-01  3.6652E-04
                                                                                  5.4839E-01  3.6217E-04
                                                                                  2.3166E-01  1.5299E-04
30.02   126.66   119.97    41.89    0.00   4.336   10.804  1.0225E-03  1.5926E-03  7.3890E-02  4.6476E-05
                                                                                  7.3890E-02  4.6476E-05
                                                                                  5.5937E-01  3.5184E-04
                                                                                  5.5498E-01  3.4907E-04
                                                                                  5.4839E-01  3.4493E-04
                                                                                  2.1897E-01  1.3773E-04
31.08   131.27   124.53    42.59    0.00   4.325   11.073  9.5386E-04  1.5197E-03  7.3890E-02  4.4348E-05
                                                                                  7.3890E-02  4.4348E-05
                                                                                  5.5937E-01  3.3573E-04
                                                                                  5.5498E-01  3.3309E-04
                                                                                  5.4839E-01  3.2914E-04
                                                                                  2.0724E-01  1.2438E-04
32.15   135.87   129.08    43.27    0.00   4.315   11.340  8.9081E-04  1.4527E-03  7.3890E-02  4.2394E-05
                                                                                  7.3890E-02  4.2394E-05
                                                                                  5.5937E-01  3.2093E-04
                                                                                  5.5498E-01  3.1841E-04
                                                                                  5.4839E-01  3.1463E-04
```

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33.22   140.48   133.64    43.95      0.00    4.304  11.602  8.3270E-04  1.3910E-03  7.3890E-02  4.0593E-05
                                                                                     7.3890E-02  4.0593E-05
                                                                                     5.5937E-01  3.0730E-04
                                                                                     5.5498E-01  3.0489E-04
                                                                                     5.4839E-01  3.0127E-04
                                                                                     1.8627E-01  1.0233E-04
34.29   145.09   138.19    44.61      0.00    4.294  11.861  7.7895E-04  1.3340E-03  7.3890E-02  3.8930E-05
                                                                                     7.3890E-02  3.8930E-05
                                                                                     5.5937E-01  2.9471E-04
                                                                                     5.5498E-01  2.9240E-04
                                                                                     5.4839E-01  2.8893E-04
                                                                                     1.7687E-01  9.3186E-05
35.36   149.69   142.75    45.27      0.00    4.285  12.116  7.2910E-04  1.2812E-03  7.3890E-02  3.7390E-05
                                                                                     7.3890E-02  3.7390E-05
                                                                                     5.5937E-01  2.8305E-04
                                                                                     5.5498E-01  2.8083E-04
                                                                                     5.4839E-01  2.7749E-04
                                                                                     1.6811E-01  8.5067E-05
36.43   154.30   147.31    45.91      0.00    4.275  12.369  6.7926E-04  1.2322E-03  7.3890E-02  3.5960E-05
                                                                                     7.3890E-02  3.5960E-05
                                                                                     5.5937E-01  2.7223E-04
                                                                                     5.5498E-01  2.7009E-04
                                                                                     5.3790E-01  2.6178E-04
                                                                                     1.5993E-01  7.7835E-05
37.51   158.90   151.87    46.54      0.00    4.266  12.617  6.3067E-04  1.1867E-03  7.3890E-02  3.4631E-05
                                                                                     7.3890E-02  3.4631E-05
                                                                                     5.5937E-01  2.6216E-04
                                                                                     5.5498E-01  2.6011E-04
                                                                                     5.2061E-01  2.4400E-04
                                                                                     1.5229E-01  7.1374E-05
38.59   163.51   156.44    47.17      0.00    4.257  12.863  5.8555E-04  1.1442E-03  7.3890E-02  3.3392E-05
                                                                                     7.3890E-02  3.3392E-05
                                                                                     5.5937E-01  2.5279E-04
                                                                                     5.5498E-01  2.5080E-04
                                                                                     5.0417E-01  2.2784E-04
                                                                                     1.4513E-01  6.5586E-05
39.68   168.11   161.00    47.78      0.00    4.248  13.105  5.4356E-04  1.1046E-03  7.3890E-02  3.2236E-05
                                                                                     7.3890E-02  3.2236E-05
                                                                                     5.5937E-01  2.4403E-04
                                                                                     5.5498E-01  2.4212E-04
                                                                                     4.8850E-01  2.1311E-04
                                                                                     1.3842E-01  6.0386E-05
40.76   172.72   165.57    48.39      0.00    4.240  13.344  5.0439E-04  1.0676E-03  7.3890E-02  3.1155E-05
                                                                                     7.3890E-02  3.1155E-05
                                                                                     5.5937E-01  2.3585E-04
                                                                                     5.5498E-01  2.3400E-04
                                                                                     4.7355E-01  1.9966E-04
                                                                                     1.3211E-01  5.5703E-05
41.85   177.32   170.13    48.98      0.00    4.231  13.580  4.6779E-04  1.0329E-03  7.3890E-02  3.0142E-05
                                                                                     7.3890E-02  3.0142E-05
                                                                                     5.5937E-01  2.2818E-04
                                                                                     5.5498E-01  2.2639E-04
                                                                                     4.5928E-01  1.8736E-04
                                                                                     1.2619E-01  5.1475E-05
42.94   181.93   174.70    49.56      0.00    4.223  13.813  4.3351E-04  1.0003E-03  7.3890E-02  2.9193E-05
                                                                                     7.3890E-02  2.9193E-05
                                                                                     5.5937E-01  2.2100E-04
                                                                                     5.5498E-01  2.1926E-04
                                                                                     4.4565E-01  1.7607E-04
                                                                                     1.2061E-01  4.7650E-05
44.03   186.53   179.27    50.14      0.00    4.215  14.042  4.0135E-04  9.6977E-04  7.3890E-02  2.8301E-05
                                                                                     7.3890E-02  2.8301E-05
                                                                                     5.5937E-01  2.1424E-04
                                                                                     5.5498E-01  2.1256E-04
                                                                                     4.3260E-01  1.6569E-04
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45.12	191.14	183.84	50.71	0.00	4.207	14.268	3.7112E-04	9.4103E-04	7.3890E-02	2.7462E-05
									7.3890E-02	2.7462E-05
									5.5937E-01	2.0789E-04
									5.5498E-01	2.0626E-04
									4.2012E-01	1.5614E-04
									1.1039E-01	4.1029E-05
46.22	195.74	188.41	51.26	0.00	4.199	14.491	3.4266E-04	9.1396E-04	7.3890E-02	2.6672E-05
									7.3890E-02	2.6672E-05
									5.5937E-01	2.0191E-04
									5.5498E-01	2.0033E-04
									4.0815E-01	1.4733E-04
									1.0571E-01	3.8159E-05
47.31	200.35	192.99	51.81	0.00	4.192	14.711	3.1582E-04	8.8843E-04	7.3890E-02	2.5927E-05
									7.3890E-02	2.5927E-05
									5.5937E-01	1.9628E-04
									5.5498E-01	1.9473E-04
									3.9668E-01	1.3919E-04
									1.0129E-01	3.5540E-05
48.41	204.96	197.56	52.35	0.00	4.184	14.928	2.9047E-04	8.6434E-04	7.3890E-02	2.5224E-05
									7.3890E-02	2.5224E-05
									5.5937E-01	1.9095E-04
									5.5498E-01	1.8945E-04
									3.8567E-01	1.3165E-04
									9.7098E-02	3.3146E-05
49.51	209.56	202.13	52.88	0.00	4.177	15.142	2.6650E-04	8.4156E-04	7.3890E-02	2.4559E-05
									7.3890E-02	2.4559E-05
									5.5937E-01	1.8592E-04
									5.5498E-01	1.8446E-04
									3.7509E-01	1.2467E-04
									9.3132E-02	3.0955E-05
50.62	214.17	206.71	53.39	0.00	4.170	15.353	2.4379E-04	8.2001E-04	7.3890E-02	2.3930E-05
									7.3890E-02	2.3930E-05
									5.5937E-01	1.8116E-04
									5.5498E-01	1.7974E-04
									3.6493E-01	1.1819E-04
									8.9373E-02	2.8945E-05
51.72	218.77	211.29	53.91	0.00	4.163	15.561	2.2227E-04	7.9960E-04	7.3890E-02	2.3335E-05
									7.3890E-02	2.3335E-05
									5.5937E-01	1.7665E-04
									5.5498E-01	1.7526E-04
									3.5515E-01	1.1216E-04
									8.5806E-02	2.7098E-05
52.83	223.38	215.87	54.41	0.00	4.156	15.766	2.0183E-04	7.8025E-04	7.3890E-02	2.2770E-05
									7.3890E-02	2.2770E-05
									5.5937E-01	1.7238E-04
									5.5498E-01	1.7102E-04
									3.4575E-01	1.0655E-04
									8.2420E-02	2.5399E-05
53.94	227.98	220.44	54.90	0.00	4.149	15.967	1.8241E-04	7.6189E-04	7.3890E-02	2.2234E-05
									7.3890E-02	2.2234E-05
									5.5937E-01	1.6832E-04
									5.5498E-01	1.6700E-04
									3.3669E-01	1.0131E-04
									7.9203E-02	2.3833E-05
55.05	232.59	225.02	55.38	0.00	4.142	16.166	1.6393E-04	7.4445E-04	7.3890E-02	2.1725E-05
									7.3890E-02	2.1725E-05
									5.5937E-01	1.6447E-04
									5.5498E-01	1.6317E-04
									3.2796E-01	9.6428E-05
									7.6143E-02	2.2388E-05
56.16	237.19	229.61	55.86	0.00	4.136	16.362	1.4634E-04	7.2788E-04	7.3890E-02	2.1241E-05
									7.3890E-02	2.1241E-05
									5.5937E-01	1.6080E-04
									5.5498E-01	1.5954E-04
									3.1955E-01	9.1862E-05

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  COLLAPSE PHASE OF THE PLUME
1  1.0000E+00  1.6459E+01     4    3  394
         T        S         X        Y         Z        U        A        B     DEN-DIF   FLUID CONC.  SOLID VOL.   CONCENTRATION
       56.72   239.50    231.90    56.09     0.00     4.13    16.46    16.46  1.3785E-04  7.1989E-04  2.9426E-01  2.1009E-05
                                                                                                     2.9426E-01  2.1009E-05
                                                                                                     2.2277E+00  1.5904E-04
                                                                                                     2.2102E+00  1.5779E-04
                                                                                                     1.2563E+00  8.9690E-05
                                                                                                     2.8605E-01  2.0422E-05
       64.68   272.38    264.68    58.65     0.00     4.12    13.22    20.61  5.3866E-05  7.1964E-04  2.9426E-01  2.1001E-05
                                                                                                     2.9426E-01  2.1001E-05
                                                                                                     2.2277E+00  1.5899E-04
                                                                                                     2.1108E+00  1.5064E-04
                                                                                                     1.0213E+00  7.2889E-05
                                                                                                     2.0968E-01  1.4964E-05
       72.65   305.16    297.44    60.18     0.00     4.12    11.43    23.84 -1.0250E-05  7.1947E-04  2.9426E-01  2.0996E-05
                                                                                                     2.9426E-01  2.0996E-05
                                                                                                     2.2277E+00  1.5895E-04
                                                                                                     1.8641E+00  1.3301E-04
                                                                                                     7.9658E-01  5.6837E-05
                                                                                                     1.4443E-01  1.0305E-05
       80.61   337.95    330.19    61.26     0.00     4.11    10.16    26.81 -6.0999E-05  7.1931E-04  2.9426E-01  2.0992E-05
                                                                                                     2.9426E-01  2.0992E-05
                                                                                                     2.2277E+00  1.5891E-04
                                                                                                     1.6181E+00  1.1543E-04
                                                                                                     6.0019E-01  4.2815E-05
                                                                                                     9.4462E-02  6.7385E-06
       88.58   370.72    362.95    62.06     0.00     4.11     9.22    29.56 -1.0438E-04  7.1916E-04  2.9426E-01  2.0987E-05
                                                                                                     2.9426E-01  2.0987E-05
                                                                                                     2.1781E+00  1.5534E-04
                                                                                                     1.3824E+00  9.8591E-05
                                                                                                     4.3804E-01  3.1241E-05
                                                                                                     5.8897E-02  4.2006E-06
       96.54   403.48    395.71    62.22     0.00     4.11     8.50    32.05 -1.3316E-04  7.1889E-04  2.8594E-01  2.0386E-05
                                                                                                     2.9426E-01  2.0979E-05
                                                                                                     2.0566E+00  1.4662E-04
                                                                                                     1.1637E+00  8.2968E-05
                                                                                                     3.1045E-01  2.2133E-05
                                                                                                     3.5142E-02  2.5054E-06
      104.51   436.24    428.47    62.29     0.00     4.11     7.94    34.33 -1.5671E-04  7.1862E-04  2.7724E-01  1.9759E-05
                                                                                                     2.9419E-01  2.0966E-05
                                                                                                     1.9334E+00  1.3779E-04
                                                                                                     9.6689E-01  6.8908E-05
                                                                                                     2.1430E-01  1.5273E-05
                                                                                                     2.0156E-02  1.4364E-06
      112.47   469.00    461.23    62.28     0.00     4.11     7.49    36.42 -1.7571E-04  7.1836E-04  2.6827E-01  1.9112E-05
                                                                                                     2.9330E-01  2.0895E-05
                                                                                                     1.8103E+00  1.2897E-04
                                                                                                     7.9368E-01  5.6544E-05
                                                                                                     1.4440E-01  1.0288E-05
                                                                                                     1.1149E-02  7.9426E-07
      120.44   501.76    493.99    62.21     0.00     4.11     7.12    38.35 -1.9058E-04  7.1811E-04  2.5911E-01  1.8453E-05
                                                                                                     2.9330E-01  2.0888E-05
                                                                                                     1.6887E+00  1.2026E-04
                                                                                                     6.4429E-01  4.5884E-05
                                                                                                     9.5158E-02  6.7769E-06
                                                                                                     5.9643E-03  4.2476E-07
      128.41   534.51    526.75    62.08     0.00     4.11     6.80    40.16 -2.0196E-04  7.1786E-04  2.4983E-01  1.7786E-05
                                                                                                     2.9330E-01  2.0881E-05
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                                                                                                      5.1763E-01  3.6851E-05
                                                                                                      6.1422E-02  4.3726E-06
                                                                                                      3.0932E-03  2.2021E-07
136.37  567.27  559.50  61.90  0.00  4.11  6.52  41.87  -2.1035E-04  7.1761E-04  2.4049E-01  1.7115E-05
                                                                                                      2.9330E-01  2.0873E-05
                                                                                                      1.4547E+00  1.0353E-04
                                                                                                      4.1185E-01  2.9310E-05
                                                                                                      3.8884E-02  2.7673E-06
                                                                                                      1.5582E-03  1.1089E-07
144.34  600.03  592.26  61.68  0.00  4.11  6.28  43.48  -2.1618E-04  7.1737E-04  2.3114E-01  1.6444E-05
                                                                                                      2.9330E-01  2.0866E-05
                                                                                                      1.3439E+00  9.5608E-05
                                                                                                      3.2471E-01  2.3101E-05
                                                                                                      2.4171E-02  1.7196E-06
                                                                                                      7.6372E-04  5.4333E-08
152.31  632.78  625.01  61.42  0.00  4.11  6.07  45.01  -2.1982E-04  7.1713E-04  2.2184E-01  1.5777E-05
                                                                                                      2.9330E-01  2.0859E-05
                                                                                                      1.2379E+00  8.8040E-05
                                                                                                      2.5380E-01  1.8050E-05
                                                                                                      1.4766E-02  1.0502E-06
                                                                                                      3.6473E-04  2.5939E-08
160.27  665.53  657.76  61.14  0.00  4.11  5.88  46.47  -2.2157E-04  7.1689E-04  2.1263E-01  1.5117E-05
                                                                                                      2.9330E-01  2.0852E-05
                                                                                                      1.1372E+00  8.0849E-05
                                                                                                      1.9674E-01  1.3988E-05
                                                                                                      8.8740E-03  6.3090E-07
                                                                                                      1.6994E-04  1.2082E-08
168.24  698.29  690.51  60.83  0.00  4.11  5.71  47.87  -2.2171E-04  7.1665E-04  2.0353E-01  1.4465E-05
                                                                                                      2.9330E-01  2.0846E-05
                                                                                                      1.0419E+00  7.4051E-05
                                                                                                      1.5132E-01  1.0755E-05
                                                                                                      5.2498E-03  3.7312E-07
                                                                                                      7.7343E-05  5.4969E-09
176.21  731.04  723.27  60.49  0.00  4.11  5.56  49.20  -2.2045E-04  7.1642E-04  1.9457E-01  1.3824E-05
                                                                                                      2.9330E-01  2.0839E-05
                                                                                                      9.5224E-01  6.7656E-05
                                                                                                      1.1552E-01  8.2076E-06
                                                                                                      3.0595E-03  2.1737E-07
                                                                                                      3.4417E-05  2.4453E-09
184.17  763.79  756.02  60.14  0.00  4.11  5.42  50.49  -2.1799E-04  7.1619E-04  1.8579E-01  1.3196E-05
                                                                                                      2.9330E-01  2.0832E-05
                                                                                                      8.6820E-01  6.1666E-05
                                                                                                      8.7554E-02  6.2187E-06
                                                                                                      1.7575E-03  1.2483E-07
                                                                                                      1.4988E-05  1.0646E-09
192.14  796.54  788.76  59.76  0.00  4.11  5.29  51.73  -2.1450E-04  7.1597E-04  1.7719E-01  1.2582E-05
                                                                                                      2.9330E-01  2.0826E-05
                                                                                                      7.8975E-01  5.6076E-05
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                                                                                                      9.9575E-04  7.0702E-08
                                                                                                      6.3936E-06  4.5397E-10
200.10  829.29  821.51  59.38  0.00  4.11  5.17  52.92  -2.1010E-04  7.1574E-04  1.6881E-01  1.1983E-05
                                                                                                      2.9330E-01  2.0819E-05
                                                                                                      7.1680E-01  5.0880E-05
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                                                                                                      5.5669E-04  3.9515E-08
                                                                                                      2.6735E-06  1.8977E-10
208.07  862.04  854.26  58.98  0.00  4.11  5.07  54.08  -2.0454E-04  7.1552E-04  1.6402E-01  1.1634E-05
                                                                                                      2.9330E-01  2.0813E-05
                                                                                                      6.4920E-01  4.6068E-05
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                                                                                                      3.0726E-04  2.1803E-08
                                                                                                      1.0967E-06  7.7824E-11
216.04  894.79  887.01  58.57  0.00  4.11  4.97  55.19  -1.9778E-04  7.1531E-04  1.6402E-01  1.1636E-05
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                                                                                                    1.6750E-04  1.1882E-08
                                                                                                    4.4158E-07  3.1325E-11
224.00   927.54   919.75   58.16    0.00    4.11    4.87   56.27 -1.9048E-04  7.1509E-04  1.6402E-01  1.1632E-05
                                                                                                    2.9330E-01  2.0800E-05
                                                                                                    5.2927E-01  3.7534E-05
                                                                                                    1.9835E-02  1.4067E-06
                                                                                                    9.0226E-05  6.3986E-09
                                                                                                    1.7465E-07  1.2386E-11
231.97   960.29   952.50   57.74    0.00    4.11    4.78   57.32 -1.8271E-04  7.1488E-04  1.6402E-01  1.1629E-05
                                                                                                    2.9330E-01  2.0794E-05
                                                                                                    4.7648E-01  3.3781E-05
                                                                                                    1.4473E-02  1.0261E-06
                                                                                                    4.8041E-05  3.4059E-09
                                                                                                    6.7888E-08  4.8130E-12
239.94   993.04   985.24   57.32    0.00    4.11    4.70   58.33 -1.7456E-04  7.1467E-04  1.6402E-01  1.1625E-05
                                                                                                    2.9330E-01  2.0788E-05
                                                                                                    4.2816E-01  3.0346E-05
                                                                                                    1.0501E-02  7.4429E-07
                                                                                                    2.5293E-05  1.7927E-09
                                                                                                    2.5949E-08  1.8391E-12
247.90  1025.78  1017.99   56.89    0.00    4.11    4.63   59.32 -1.6609E-04  7.1446E-04  1.6402E-01  1.1622E-05
                                                                                                    2.9330E-01  2.0782E-05
                                                                                                    3.8404E-01  2.7212E-05
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                                                                                                    1.3173E-05  9.3335E-10
                                                                                                    9.7583E-09  6.9142E-13
255.87  1058.53  1050.73   56.46    0.00    4.11    4.55   60.28 -1.5736E-04  7.1426E-04  1.6402E-01  1.1619E-05
                                                                                                    2.9330E-01  2.0776E-05
                                                                                                    3.4387E-01  2.4358E-05
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                                                                                                    6.7881E-06  4.8084E-10
                                                                                                    3.6122E-09  2.5587E-13
263.84  1091.27  1083.47   56.03    0.00    4.11    4.49   61.21 -1.4842E-04  7.1406E-04  1.6402E-01  1.1615E-05
                                                                                                    2.9330E-01  2.0770E-05
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                                                                                                    3.8849E-03  2.7510E-07
                                                                                                    3.4623E-06  2.4518E-10
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271.80  1124.02  1116.21   55.60    0.00    4.11    4.42   62.12 -1.3932E-04  7.1386E-04  1.6402E-01  1.1612E-05
                                                                                                    2.9330E-01  2.0764E-05
                                                                                                    2.7428E-01  1.9417E-05
                                                                                                    2.7605E-03  1.9543E-07
                                                                                                    1.7485E-06  1.2378E-10
                                                                                                    4.7288E-10  3.3477E-14
279.77  1156.76  1148.96   55.18    0.00    4.11    4.36   63.00 -1.3010E-04  7.1366E-04  1.6402E-01  1.1609E-05
                                                                                                    2.9330E-01  2.0759E-05
                                                                                                    2.4436E-01  1.7295E-05
                                                                                                    1.9521E-03  1.3816E-07
                                                                                                    8.7443E-07  6.1888E-11
                                                                                                    1.6738E-10  1.1846E-14
287.74  1189.51  1181.70   54.75    0.00    4.11    4.30   63.86 -1.2079E-04  7.1346E-04  1.6402E-01  1.1606E-05
                                                                                                    2.9330E-01  2.0753E-05
                                                                                                    2.1736E-01  1.5380E-05
                                                                                                    1.3739E-03  9.7214E-08
                                                                                                    4.3320E-07  3.0652E-11
                                                                                                    5.8416E-11  4.1333E-15
295.70  1222.25  1214.44   54.33    0.00    4.11    4.25   64.70 -1.1144E-04  7.1327E-04  1.6402E-01  1.1603E-05
                                                                                                    2.9330E-01  2.0747E-05
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                                                                                                    2.1265E-07  1.5042E-11
                                                                                                    2.0109E-11  1.4225E-15
303.67  1254.99  1247.18   53.92    0.00    4.11    4.20   65.52 -1.0207E-04  7.1308E-04  1.6402E-01  1.1599E-05
                                                                                                    2.9330E-01  2.0742E-05
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                                                                                                  6.7133E-04  4.7476E-08
                                                                                                  1.0345E-07  7.3160E-12
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311.64  1287.73  1279.92   53.50    0.00    4.11    4.15   66.32 -9.2717E-05  7.1290E-04  1.6402E-01  1.1596E-05
                                                                                                  2.9330E-01  2.0736E-05
                                                                                                  1.5160E-01  1.0718E-05
                                                                                                  4.6618E-04  3.2959E-08
                                                                                                  4.9892E-08  3.5274E-12
                                                                                                  2.2901E-12  1.6191E-16
319.60  1320.48  1312.65   53.10    0.00    4.11    4.10   67.09 -8.3400E-05  7.1271E-04  1.6402E-01  1.1593E-05
                                                                                                  2.9330E-01  2.0731E-05
                                                                                                  1.3406E-01  9.4755E-06
                                                                                                  3.2234E-04  2.2784E-08
                                                                                                  2.3856E-08  1.6863E-12
                                                                                                  7.5813E-13  5.3586E-17
327.57  1353.22  1345.39   52.70    0.00    4.11    4.06   67.86 -7.4629E-05  7.1253E-04  1.5981E-01  1.1293E-05
                                                                                                  2.9330E-01  2.0726E-05
                                                                                                  1.1838E-01  8.3652E-06
                                                                                                  2.2196E-04  1.5685E-08
                                                                                                  1.1314E-08  7.9948E-13
                                                                                                  2.4789E-13  1.7516E-17
335.53  1385.96  1378.13   52.31    0.00    4.11    4.01   68.60 -6.6577E-05  7.1235E-04  1.5008E-01  1.0602E-05
                                                                                                  2.9330E-01  2.0720E-05
                                                                                                  1.0440E-01  7.3751E-06
                                                                                                  1.5222E-04  1.0754E-08
                                                                                                  5.3221E-09  3.7598E-13
                                                                                                  8.0078E-14  5.6572E-18
343.50  1418.70  1410.87   51.92    0.00    4.11    3.97   69.32 -5.8566E-05  7.1217E-04  1.4084E-01  9.9472E-06
                                                                                                  2.9330E-01  2.0715E-05
                                                                                                  9.1940E-02  6.4936E-06
                                                                                                  1.0398E-04  7.3440E-09
                                                                                                  2.4838E-09  1.7543E-13
                                                                                                  2.5566E-14  1.8057E-18
351.47  1451.44  1443.61   51.54    0.00    4.11    3.93   70.03 -5.0614E-05  7.1200E-04  1.3209E-01  9.3267E-06
                                                                                                  2.9330E-01  2.0710E-05
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                                                                                                  1.1503E-09  8.1221E-14
                                                                                                  8.0689E-15  5.6975E-19
359.43  1484.17  1476.34   51.17    0.00    4.11    3.89   70.73 -4.2737E-05  7.1182E-04  1.2380E-01  8.7394E-06
                                                                                                  2.9330E-01  2.0705E-05
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                                                                                                  5.2870E-10  3.7323E-14
                                                                                                  2.5182E-15  1.7777E-19
367.40  1516.91  1509.08   50.80    0.00    4.11    3.86   71.40 -3.4950E-05  7.1165E-04  1.1596E-01  8.1841E-06
                                                                                                  2.9330E-01  2.0700E-05
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                                                                                                  2.4122E-10  1.7025E-14
                                                                                                  7.7732E-16  5.4860E-20
375.37  1549.65  1541.81   50.45    0.00    4.11    3.82   72.07 -2.7268E-05  7.1149E-04  1.0855E-01  7.6595E-06
                                                                                                  2.9330E-01  2.0695E-05
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                                                                                                  2.1801E-05  1.5383E-09
                                                                                                  1.0927E-10  7.7101E-15
                                                                                                  2.3739E-16  1.6750E-20
383.33  1582.39  1574.55   50.10    0.00    4.11    3.79   72.72 -1.9702E-05  7.1132E-04  1.0156E-01  7.1643E-06
                                                                                                  2.9330E-01  2.0691E-05
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                                                                                                  1.4620E-05  1.0313E-09
                                                                                                  4.9151E-11  3.4673E-15
                                                                                                  7.1742E-17  5.0609E-21
391.30  1615.12  1607.28   49.76    0.00    4.11    3.76   73.35 -1.2267E-05  7.1116E-04  9.4961E-02  6.6974E-06
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                                                                                            2.9330E-01  2.0681E-05
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                                                                                            6.5076E-06  4.5886E-10
                                                                                            9.7432E-12  6.8700E-16
                                                                                            6.3560E-18  4.4817E-22
 407.23  1680.60  1672.75   49.11    0.00    4.11    3.70   74.58  2.1721E-06  7.1084E-04  8.2885E-02  5.8431E-06
                                                                                            2.9330E-01  2.0676E-05
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                                                                                            4.3202E-06  3.0455E-10
                                                                                            4.2951E-12  3.0278E-16
                                                                                            1.8641E-18  1.3141E-22
 415.20  1713.33  1705.49   48.80    0.00    4.11    3.67   75.17  9.1553E-06  7.1068E-04  7.7373E-02  5.4533E-06
                                                                                            2.9330E-01  2.0672E-05
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                                                                                            2.8588E-06  2.0149E-10
                                                                                            1.8813E-12  1.3259E-16
                                                                                            5.4152E-19  3.8166E-23
 423.17  1746.07  1738.22   48.49    0.00    4.11    3.64   75.76  1.5969E-05  7.1053E-04  7.2190E-02  5.0868E-06
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                                                                                            8.1883E-13  5.7699E-17
                                                                                            1.5585E-19  1.0982E-23
 431.13  1778.80  1770.96   48.20    0.00    4.11    3.62   76.33  2.2605E-05  7.1037E-04  6.7319E-02  4.7426E-06
                                                                                            2.9330E-01  2.0663E-05
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                                                                                            3.5422E-13  2.4954E-17
                                                                                            4.4444E-20  3.1311E-24
 439.10  1811.54  1803.69   47.92    0.00    4.11    3.59   76.88  2.9056E-05  7.1022E-04  6.2745E-02  4.4194E-06
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                                                                                            1.2562E-20  8.8479E-25
 447.06  1844.27  1836.42   47.64    0.00    4.11    3.57   77.43  3.5315E-05  7.1008E-04  5.8454E-02  4.1163E-06
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                                                                                            9.7773E-22  6.8837E-26
 463.00  1909.74  1901.89   47.12    0.00    4.11    3.52   78.49  4.7234E-05  7.0979E-04  5.0658E-02  3.5659E-06
                                                                                            2.9330E-01  2.0646E-05
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                                                                                            1.1694E-14  8.2318E-19
                                                                                            2.6934E-22  1.8960E-26
 470.96  1942.47  1934.62   46.87    0.00    4.11    3.50   79.00  5.2883E-05  7.0964E-04  4.7126E-02  3.3166E-06
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                                                                                            7.3594E-23  5.1794E-27
 478.93  1975.21  1967.35   46.64    0.00    4.11    3.48   79.51  5.8319E-05  7.0951E-04  4.3821E-02  3.0834E-06
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                                                                                              4.0730E-02  2.8653E-06
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                                                                                              8.5432E-16  6.0102E-20
                                                                                              5.3647E-24  3.7741E-28
 494.86  2040.67  2032.82   46.20    0.00    4.11    3.44   80.48  6.8536E-05  7.0923E-04   3.7840E-02  2.6615E-06
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                                                                                              1.4317E-24  1.0070E-28
 502.83  2073.40  2065.55   45.99    0.00    4.11    3.42   80.96  7.3310E-05  7.0910E-04   3.5140E-02  2.4712E-06
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 510.80  2106.14  2098.28   45.80    0.00    4.11    3.40   81.42  7.7857E-05  7.0897E-04   3.2620E-02  2.2935E-06
                                                                                              2.9330E-01  2.0622E-05
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                                                                                              2.4275E-17  1.7065E-21
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                                                                                              2.9330E-01  2.0615E-05
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                                                                                              6.7479E-27  4.7428E-31
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                                                                                              1.7372E-27  1.2207E-31
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 558.60  2302.52  2294.66   44.83    0.00    4.11    3.30   84.02  1.0029E-04  7.0822E-04   2.0699E-02  1.4538E-06
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 566.56  2335.25  2327.39   44.71    0.00    4.11    3.28   84.42  1.0321E-04  7.0810E-04   1.9163E-02  1.3457E-06
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                                                                                                1.0857E-31  7.6205E-36
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606.39  2498.90  2491.04  44.23   0.00   4.11   3.21  86.31  1.1432E-04  7.0754E-04  1.2965E-02  9.0975E-07
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                                                                                                6.4699E-33  4.5398E-37
614.36  2531.63  2523.77  44.16   0.00   4.11   3.20  86.67  1.1586E-04  7.0743E-04  1.1979E-02  8.4042E-07
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630.29  2597.09  2589.23  44.06   0.00   4.11   3.17  87.36  1.1824E-04  7.0722E-04  1.0216E-02  7.1655E-07
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                                                                                                9.0279E-35  6.3319E-39
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                                                                                                2.1504E-35  1.5080E-39
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                                                                                                7.8191E-24  5.4825E-28
                                                                                                5.0959E-36  3.5731E-40
654.19  2695.28  2687.42  43.97   0.00   4.11   3.14  88.35  1.1948E-04  7.0692E-04  8.0287E-03  5.6288E-07
                                                                                                2.8727E-01  2.0140E-05
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                                                                                                      3.5701E-12  2.5029E-16
                                                                                                      2.9740E-24  2.0850E-28
                                                                                                      1.2015E-36  8.4237E-41
662.16  2728.01  2720.15   43.96    0.00    4.11    3.13   88.67  1.1943E-04  7.0683E-04  7.4049E-03  5.1907E-07
                                                                                                      2.8496E-01  1.9975E-05
                                                                                                      2.5415E-04  1.7816E-08
                                                                                                      2.1974E-12  1.5403E-16
                                                                                                      1.1274E-24  7.9026E-29
                                                                                                      2.8191E-37  1.9761E-41
670.13  2760.74  2752.88   43.95    0.00    4.11    3.12   88.98  1.1918E-04  7.0673E-04  6.8276E-03  4.7854E-07
                                                                                                      2.8266E-01  1.9811E-05
                                                                                                      2.1607E-04  1.5144E-08
                                                                                                      1.3503E-12  9.4637E-17
                                                                                                      4.2595E-25  2.9854E-29
                                                                                                      6.5825E-38  4.6136E-42
678.09  2793.47  2785.61   43.96    0.00    4.11    3.11   89.28  1.1872E-04  7.0664E-04  6.2936E-03  4.4105E-07
                                                                                                      2.8036E-01  1.9648E-05
                                                                                                      1.8359E-04  1.2866E-08
                                                                                                      8.2836E-13  5.8051E-17
                                                                                                      1.6042E-25  1.1242E-29
                                                                                                      1.5297E-38  1.0720E-42
686.06  2826.19  2818.33   43.97    0.00    4.11    3.10   89.58  1.1807E-04  7.0655E-04  5.7999E-03  4.0640E-07
                                                                                                      2.7808E-01  1.9485E-05
                                                                                                      1.5592E-04  1.0925E-08
                                                                                                      5.0739E-13  3.5553E-17
                                                                                                      6.0227E-26  4.2201E-30
                                                                                                      3.5386E-39  2.4795E-43
694.02  2858.92  2851.06   43.99    0.00    4.11    3.09   89.87  1.1722E-04  7.0646E-04  5.3435E-03  3.7437E-07
                                                                                                      2.7581E-01  1.9324E-05
                                                                                                      1.3235E-04  9.2723E-09
                                                                                                      3.1030E-13  2.1740E-17
                                                                                                      2.2541E-26  1.5793E-30
                                                                                                      8.1484E-40  5.7089E-44
701.99  2891.65  2883.79   44.02    0.00    4.11    3.08   90.16  1.1618E-04  7.0637E-04  4.9218E-03  3.4478E-07
                                                                                                      2.7355E-01  1.9163E-05
                                                                                                      1.1228E-04  7.8655E-09
                                                                                                      1.8948E-13  1.3274E-17
                                                                                                      8.4111E-27  5.8922E-31
                                                                                                      1.8681E-40  1.3086E-44
709.96  2924.38  2916.52   44.06    0.00    4.11    3.07   90.44  1.1498E-04  7.0628E-04  4.5322E-03  3.1745E-07
                                                                                                      2.7149E-01  1.9017E-05
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                                                                                                      1.1553E-13  8.0925E-18
                                                                                                      3.1293E-27  2.1919E-31
                                                                                                      4.2640E-41  2.9867E-45
717.92  2957.11  2949.25   44.10    0.00    4.11    3.06   90.71  1.1384E-04  7.0620E-04  4.1725E-03  2.9222E-07
                                                                                                      2.7149E-01  1.9014E-05
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                                                                                                      7.0342E-14  4.9265E-18
                                                                                                      1.1608E-27  8.1299E-32
                                                                                                      9.6917E-42  6.7876E-46
725.89  2989.84  2981.98   44.15    0.00    4.11    3.05   90.98  1.1252E-04  7.0611E-04  3.8404E-03  2.6893E-07
                                                                                                      2.7149E-01  1.9012E-05
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                                                                                                      4.2767E-14  2.9948E-18
                                                                                                      4.2940E-28  3.0070E-32
                                                                                                      2.1937E-42  1.5362E-46
733.86  3022.56  3014.70   44.21    0.00    4.11    3.04   91.25  1.1103E-04  7.0603E-04  3.5334E-03  2.4744E-07
                                                                                                      2.7149E-01  1.9010E-05
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                                                                                                      1.5840E-28  1.1091E-32
                                                                                                      4.9451E-43  3.4625E-47
741.82  3055.29  3047.43   44.27    0.00    4.11    3.04   91.50  1.0938E-04  7.0595E-04  3.2511E-03  2.2761E-07
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                                                                                    1.5742E-14  1.1021E-18
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                                                                                    1.1103E-43  7.7734E-48
749.79  3088.02  3080.16  44.34   0.00   4.11   3.03   91.76  1.0756E-04  7.0587E-04  2.9903E-03  2.0933E-07
                                                                                    2.7149E-01  1.9005E-05
                                                                                    4.1446E-05  2.9014E-09
                                                                                    9.5319E-15  6.6726E-19
                                                                                    2.1379E-29  1.4966E-33
                                                                                    2.4832E-44  1.7383E-48
757.76  3120.75  3112.89  44.42   0.00   4.11   3.02   92.00  1.0560E-04  7.0579E-04  2.7498E-03  1.9247E-07
                                                                                    2.7149E-01  1.9003E-05
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                                                                                    5.7639E-15  4.0344E-19
                                                                                    7.8235E-30  5.4761E-34
                                                                                    5.5326E-45  3.8725E-49
765.72  3153.47  3145.61  44.50   0.00   4.11   3.01   92.25  1.0348E-04  7.0571E-04  2.5281E-03  1.7694E-07
                                                                                    2.7149E-01  1.9001E-05
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                                                                                    3.4809E-15  2.4362E-19
                                                                                    2.8556E-30  1.9986E-34
                                                                                    1.2280E-45  8.5948E-50
773.69  3186.20  3178.34  44.59   0.00   4.11   3.01   92.48  1.0122E-04  7.0564E-04  2.3238E-03  1.6262E-07
                                                                                    2.7149E-01  1.8999E-05
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                                                                                    2.0995E-15  1.4693E-19
                                                                                    1.0397E-30  7.2758E-35
                                                                                    2.7159E-46  1.9006E-50
781.66  3218.93  3211.07  44.69   0.00   4.11   3.00   92.72  9.8818E-05  7.0557E-04  2.1356E-03  1.4943E-07
                                                                                    2.7149E-01  1.8997E-05
                                                                                    2.1139E-05  1.4792E-09
                                                                                    1.2648E-15  8.8501E-20
                                                                                    3.7762E-31  2.6423E-35
                                                                                    5.9847E-47  4.1877E-51
789.62  3251.66  3243.80  44.79   0.00   4.11   2.99   92.94  9.6288E-05  7.0549E-04  1.9622E-03  1.3729E-07
                                                                                    2.7149E-01  1.8995E-05
                                                                                    1.7846E-05  1.2486E-09
                                                                                    7.6101E-16  5.3245E-20
                                                                                    1.3682E-31  9.5728E-36
                                                                                    1.3142E-47  9.1948E-52
797.59  3284.39  3276.52  44.89   0.00   4.11   2.98   93.17  9.3632E-05  7.0542E-04  1.8025E-03  1.2610E-07
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                                                                                    4.5735E-16  3.1996E-20
                                                                                    4.9458E-32  3.4600E-36
                                                                                    2.8760E-48  2.0120E-52
805.56  3317.11  3309.25  45.00   0.00   4.11   2.98   93.38  9.0856E-05  7.0535E-04  1.6555E-03  1.1581E-07
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                                                                                    2.7454E-16  1.9205E-20
                                                                                    1.7837E-32  1.2477E-36
                                                                                    6.2726E-49  4.3878E-53
813.52  3349.84  3341.98  45.12   0.00   4.11   2.97   93.60  8.7967E-05  7.0528E-04  1.5203E-03  1.0633E-07
                                                                                    2.7149E-01  1.8990E-05
                                                                                    1.0713E-05  7.4929E-10
                                                                                    1.6462E-16  1.1514E-20
                                                                                    6.4184E-33  4.4893E-37
                                                                                    1.3636E-49  9.5376E-54
821.49  3382.57  3374.71  45.24   0.00   4.11   2.96   93.81  8.4970E-05  7.0522E-04  1.3958E-03  9.7618E-08
                                                                                    2.7149E-01  1.8988E-05
                                                                                    9.0300E-06  6.3154E-10
                                                                                    9.8598E-17  6.8958E-21
                                                                                    2.3045E-33  1.6117E-37
                                                                                    2.9548E-50  2.0665E-54
829.45  3415.29  3407.43  45.36   0.00   4.11   2.96   94.01  8.1872E-05  7.0515E-04  1.2812E-03  8.9600E-08
                                                                                    2.7149E-01  1.8986E-05
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                                                                                                     5.8991E-17  4.1254E-21
                                                                                                     8.2564E-34  5.7739E-38
                                                                                                     6.3826E-51  4.4635E-55
837.42  3448.02  3440.16   45.49    0.00    4.11    2.95   94.21  7.8680E-05  7.0509E-04  1.1759E-03  8.2226E-08
                                                                                                     2.7149E-01  1.8984E-05
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                                                                                                     2.9518E-34  2.0641E-38
_____________________________________________________________________________________________________1.3745E-51  9.6110E-56
845.39  3480.75  3472.89   45.62    0.00    4.11    2.95   94.41  7.5400E-05  7.0502E-04  1.0790E-03  7.5446E-08
                                                                                                     2.7149E-01  1.8983E-05
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                                                                                                     1.0532E-34  7.3636E-39
_____________________________________________________________________________________________________2.9510E-52  2.0633E-56
853.35  3513.48  3505.61   45.75    0.00    4.11    2.94   94.60  7.2037E-05  7.0496E-04  9.9000E-04  6.9214E-08
                                                                                                     2.7149E-01  1.8981E-05
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                                                                                                     3.7499E-35  2.6217E-39
_____________________________________________________________________________________________________6.3171E-53  4.4165E-57
861.32  3546.20  3538.34   45.89    0.00    4.11    2.94   94.79  6.8599E-05  7.0490E-04  9.0814E-04  6.3486E-08
                                                                                                     2.7149E-01  1.8979E-05
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                                                                                                     1.3326E-35  9.3156E-40
_____________________________________________________________________________________________________1.3484E-53  9.4263E-58
869.29  3578.93  3571.07   46.03    0.00    4.11    2.93   94.97  6.5093E-05  7.0484E-04  8.3292E-04  5.8222E-08
                                                                                                     2.7149E-01  1.8978E-05
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                                                                                                     4.4532E-18  3.1129E-22
                                                                                                     4.7263E-36  3.3037E-40
_____________________________________________________________________________________________________2.8701E-54  2.0062E-58
877.25  3611.66  3603.79   46.17    0.00    4.11    2.92   95.15  6.1523E-05  7.0478E-04  7.6381E-04  5.3387E-08
                                                                                                     2.7149E-01  1.8976E-05
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                                                                                                     1.6731E-36  1.1694E-40
_____________________________________________________________________________________________________6.0924E-55  4.2583E-59
885.22  3644.38  3636.52   46.32    0.00    4.11    2.92   95.33  5.7898E-05  7.0473E-04  7.0033E-04  4.8946E-08
                                                                                                     2.7149E-01  1.8975E-05
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                                                                                                     5.9121E-37  4.1320E-41
_____________________________________________________________________________________________________1.2897E-55  9.0140E-60
893.19  3677.11  3669.25   46.46    0.00    4.11    2.91   95.50  5.4223E-05  7.0467E-04  6.4203E-04  4.4867E-08
                                                                                                     2.7149E-01  1.8973E-05
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                                                                                                     2.0853E-37  1.4573E-41
_____________________________________________________________________________________________________2.7232E-56  1.9031E-60
901.15  3709.84  3701.97   46.61    0.00    4.11    2.91   95.67  5.0504E-05  7.0462E-04  5.8849E-04  4.1123E-08
                                                                                                     2.7149E-01  1.8972E-05
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                                                                                                     7.3422E-38  5.1306E-42
_____________________________________________________________________________________________________5.7350E-57  4.0076E-61
909.12  3742.56  3734.70   46.76    0.00    4.11    2.91   95.83  4.6749E-05  7.0456E-04  5.3934E-04  3.7685E-08
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                                                                                                     2.5807E-38  1.8032E-42
_____________________________________________________________________________________________________1.2048E-57  8.4181E-62
917.09  3775.29  3767.42   46.91    0.00    4.11    2.90   95.99  4.2963E-05  7.0451E-04  4.9422E-04  3.4530E-08
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                                                                                                          2.5247E-58  1.7639E-62
  925.05  3808.02  3800.15   47.06    0.00    4.11    2.90   96.15  3.9153E-05  7.0446E-04  4.5282E-04  3.1635E-08
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                                                                                                          1.1499E-19  8.0334E-24
                                                                                                          3.1723E-39  2.2163E-43
                                                                                                          5.2779E-59  3.6873E-63
  933.02  3840.74  3832.88   47.22    0.00    4.11    2.89   96.30  3.5325E-05  7.0441E-04  4.1482E-04  2.8979E-08
                                                                                                          2.7149E-01  1.8966E-05
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                                                                                                          6.7970E-20  4.7483E-24
                                                                                                          1.1095E-39  7.7509E-44
                                                                                                          1.1008E-59  7.6899E-64
  940.98  3873.47  3865.60   47.37    0.00    4.11    2.89   96.45  3.1485E-05  7.0436E-04  3.7997E-04  2.6542E-08
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                                                                                                          4.0146E-20  2.8043E-24
                                                                                                          3.8745E-40  2.7065E-44
                                                                                                          2.2906E-60  1.6001E-64
  948.95  3906.19  3898.33   47.52    0.00    4.11    2.88   96.60  2.7639E-05  7.0431E-04  3.4800E-04  2.4307E-08
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                                                                                                          2.3693E-20  1.6550E-24
                                                                                                          1.3509E-40  9.4359E-45
                                                                                                          4.7558E-61  3.3219E-65
  956.92  3938.92  3931.05   47.68    0.00    4.11    2.88   96.74  2.3793E-05  7.0426E-04  3.1868E-04  2.2258E-08
                                                                                                          2.7149E-01  1.8962E-05
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                                                                                                          1.3973E-20  9.7592E-25
                                                                                                          4.7031E-41  3.2848E-45
                                                                                                          9.8527E-62  6.8815E-66
  964.88  3971.65  3963.78   47.83    0.00    4.11    2.88   96.88  1.9953E-05  7.0422E-04  2.9179E-04  2.0379E-08
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                                                                                                          8.2343E-21  5.7508E-25
                                                                                                          1.6350E-41  1.1418E-45
                                                                                                          2.0368E-62  1.4225E-66
  972.85  4004.37  3996.50   47.98    0.00    4.11    2.87   97.02  1.6125E-05  7.0417E-04  2.6714E-04  1.8656E-08
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                                                                                                          4.8490E-21  3.3863E-25
                                                                                                          5.6755E-42  3.9635E-46
                                                                                                          4.2020E-63  2.9344E-67
  980.82  4037.10  4029.23   48.14    0.00    4.11    2.87   97.15  1.2315E-05  7.0413E-04  2.4455E-04  1.7077E-08
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                                                                                                          1.9674E-42  1.3739E-46
                                                                                                          8.6511E-64  6.0411E-68
  988.78  4069.82  4061.96   48.29    0.00    4.11    2.86   97.28  8.5277E-06  7.0409E-04  2.2384E-04  1.5630E-08
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                                                                                                          6.8108E-43  4.7557E-47
                                                                                                          1.7776E-64  1.2412E-68
  996.75  4102.55  4094.68   48.44    0.00    4.11    2.86   97.41  4.7689E-06  7.0405E-04  2.0486E-04  1.4304E-08
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                                                                                                          9.8612E-22  6.8853E-26
                                                                                                          2.3546E-43  1.6440E-47
                                                                                                          3.6453E-65  2.5452E-69
 1004.72  4135.27  4127.41   48.59    0.00    4.11    2.86   97.54  1.0439E-06  7.0400E-04  1.8747E-04  1.3089E-08
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                                                                                                7.4615E-66  5.2095E-70
1012.68  4168.00  4160.13  48.73   0.00    4.11    2.85   97.66 -2.6421E-06  7.0396E-04  1.7153E-04  1.1975E-08
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                                                                                                2.8034E-44  1.9571E-48
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1020.65  4200.73  4192.86  48.88   0.00    4.11    2.85   97.77 -6.2841E-06  7.0393E-04  1.5694E-04  1.0956E-08
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                                                                                                9.6549E-45  6.7401E-49
------------------------------------------------------------------------------------------------3.1091E-67  2.1705E-71
1028.62  4233.45  4225.58  49.02   0.00    4.11    2.85   97.89 -9.8771E-06  7.0389E-04  1.4357E-04  1.0022E-08
                                                                                                2.7149E-01  1.8952E-05
------------------------------------------------------------------------------------------------9.5543E-08  6.6695E-12
                                                                                                1.1687E-22  8.1580E-27
                                                                                                3.3212E-45  2.3184E-49
------------------------------------------------------------------------------------------------6.3297E-68  4.4186E-72
1036.58  4266.18  4258.31  49.16   0.00    4.11    2.84   98.00 -1.3416E-05  7.0385E-04  1.3133E-04  9.1672E-09
                                                                                                2.7149E-01  1.8951E-05
------------------------------------------------------------------------------------------------7.9945E-08  5.5803E-12
                                                                                                6.8465E-23  4.7791E-27
                                                                                                1.1411E-45  7.9652E-50
------------------------------------------------------------------------------------------------1.2865E-68  8.9798E-73
1044.55  4298.90  4291.03  49.30   0.00    4.11    2.84   98.11 -1.6898E-05  7.0381E-04  1.2012E-04  8.3843E-09
                                                                                                2.7149E-01  1.8950E-05
------------------------------------------------------------------------------------------------6.6880E-08  4.6681E-12
                                                                                                4.0087E-23  2.7980E-27
                                                                                                3.9161E-46  2.7334E-50
------------------------------------------------------------------------------------------------2.6103E-69  1.8219E-73
1052.52  4331.63  4323.76  49.44   0.00    4.11    2.84   98.22 -2.0316E-05  7.0378E-04  1.0986E-04  7.6676E-09
                                                                                                2.7149E-01  1.8949E-05
------------------------------------------------------------------------------------------------5.5940E-08  3.9043E-12
                                                                                                2.3458E-23  1.6372E-27
                                                                                                1.3425E-46  9.3699E-51
------------------------------------------------------------------------------------------------5.2877E-70  3.6906E-74
1060.48  4364.35  4356.48  49.57   0.00    4.11    2.83   98.32 -2.3667E-05  7.0374E-04  1.0046E-04  7.0115E-09
                                                                                                2.7149E-01  1.8948E-05
------------------------------------------------------------------------------------------------4.6781E-08  3.2649E-12
                                                                                                1.3719E-23  9.5751E-28
                                                                                                4.5971E-47  3.2084E-51
------------------------------------------------------------------------------------------------1.0695E-70  7.4639E-75
1068.45  4397.08  4389.21  49.71   0.00    4.11    2.83   98.42 -2.6948E-05  7.0371E-04  9.1862E-05  6.4109E-09
                                                                                                2.7149E-01  1.8947E-05
------------------------------------------------------------------------------------------------3.9114E-08  2.7297E-12
                                                                                                8.0196E-24  5.5968E-28
                                                                                                1.5725E-47  1.0974E-51
------------------------------------------------------------------------------------------------2.1597E-71  1.5072E-75
1076.41  4429.80  4421.93  49.83   0.00    4.11    2.83   98.52 -3.0153E-05  7.0368E-04  8.3991E-05  5.8613E-09
                                                                                                2.7149E-01  1.8946E-05
------------------------------------------------------------------------------------------------3.2698E-08  2.2819E-12
                                                                                                4.6853E-24  3.2697E-28
                                                                                                5.3735E-48  3.7499E-52
------------------------------------------------------------------------------------------------4.3547E-72  3.0390E-76
1084.38  4462.53  4454.65  49.96   0.00    4.11    2.83   98.62 -3.3280E-05  7.0364E-04  7.6788E-05  5.3584E-09
                                                                                                2.7149E-01  1.8946E-05
------------------------------------------------------------------------------------------------2.7330E-08  1.9072E-12
                                                                                                2.7360E-24  1.9092E-28
                                                                                                1.8344E-48  1.2801E-52
------------------------------------------------------------------------------------------------8.7681E-73  6.1186E-77
1092.35  4495.25  4487.38  50.08   0.00    4.11    2.82   98.71 -3.6325E-05  7.0361E-04  7.0197E-05  4.8983E-09
                                                                                                2.7149E-01  1.8945E-05
                                                                                                1.5969E-24  1.1143E-28
                                                                                                6.2558E-49  4.3653E-53
                                                                                                1.7629E-73  1.2301E-77
1100.31  4527.98  4520.10   50.20    0.00    4.11    2.82   98.80 -3.9283E-05  7.0358E-04  6.4166E-05  4.4773E-09
                                                                                                2.7149E-01  1.8944E-05
                                                                                                1.9084E-08  1.3316E-12
                                                                                                9.3157E-25  6.5001E-29
                                                                                                2.1314E-49  1.4872E-53
                                                                                                3.5396E-74  2.4698E-78
1108.28  4560.70  4552.83   50.31    0.00    4.11    2.82   98.89 -4.2153E-05  7.0355E-04  5.8649E-05  4.0921E-09
                                                                                                2.7149E-01  1.8943E-05
                                                                                                1.5943E-08  1.1124E-12
                                                                                                5.4320E-25  3.7901E-29
                                                                                                7.2553E-50  5.0623E-54
                                                                                                7.0972E-75  4.9520E-79
1116.25  4593.42  4585.55   50.42    0.00    4.11    2.82   98.98 -4.4931E-05  7.0352E-04  5.3602E-05  3.7398E-09
                                                                                                2.7149E-01  1.8942E-05
                                                                                                1.3318E-08  9.2917E-13
                                                                                                3.1660E-25  2.2089E-29
                                                                                                2.4674E-50  1.7215E-54
                                                                                                1.4212E-75  9.9159E-80
1124.21  4626.15  4618.28   50.53    0.00    4.11    2.81   99.06 -4.7615E-05  7.0350E-04  4.8986E-05  3.4176E-09
                                                                                                2.7149E-01  1.8942E-05
                                                                                                1.1123E-08  7.7600E-13
                                                                                                1.8444E-25  1.2868E-29
                                                                                                8.3841E-51  5.8494E-55
                                                                                                2.8424E-76  1.9830E-80
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